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: $720,890

Total Amount of Proposed Project: $1,095,218

Duration of Project: 10 months

Point of Contact (POC): Calvin Liu

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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).

ElectroGrow has developed a gliding arc reactor which ionizes methane from CH4 to CH2 and CH3. Pumping the CH2 and CH3 into an existing oil or natural gas liquids (NGLs) causes the CH2 and CH3 ions to chemically bond to existing oil and NGL hydrocarbons. The result is a higher volume of heavier oil.

The North Dakota Pipeline Authority director, Justin Kringstad, has predicted a glut of five hundred million to one billion cubic feet of natural gas per day in North Dakota by 2027 – a glut which, due to North Dakota's ground breaking anti-flaring laws, will force reduction in oil production of up to two million barrels per day, which in turn will reduce state tax revenue by one hundred million dollars a year.

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.

Economically: the ability to convert natural gas to oil will increase its dollar per unit of heat value by five times or more. The dollar per unit heat value of natural gas at present is a small fraction as compared to the same dollar per unit heat value of oil. The heat content of six thousand cubic feet (6 mcf) of natural gas corresponds to the heat content of one barrel of oil, but the rough present market prices of 6 mcf is $12 as compared to $60 for one barrel of oil.

The capability to convert natural gas to oil also potentially enables economic utilization of low production natural gas wells; reduction of flaring due to in-process infrastructure buildout to new wells; smoothing out of income from natural gas via linkage to a different energy market (oil) and said market's low correlation to natural gas prices, and very likely other beneficial economic scenarios.

This grant request is to enable ElectroGrow to accelerate the deployment of field production versions of its technology, along with proofs of concept for distributed, well head, post cleaning plant and pipeline operation. The scale required to address the potential North Dakota natural gas glut is such that manufacturing lines will need to be created; the proofs of concept will demonstrate the viability of ElectroGrow technology in the field such that natural gas industry partners will face less hurdles to adoption and that funding can be obtained to scale to the opportunity.

2027 is not very far away given these requirements and challenges.

Expected Results:

Demonstrate methane liquefaction capability to economically profitable rates.

Demonstrate methane liquefaction capability in field conditions at multiple natural gas production stages

Duration:

10 months

Total Project Cost:

$1,095,218

Participants:

ElectroGrow

EERC

Industry partner (TBD)

PROJECT DESCRIPTION

Objectives:

Demonstrate methane liquefaction in the field

Demonstrate methane liquefaction at multiple stages in the natural gas production life cycle

Prove that the ElectroGrow new architecture is operationally capable and is economically viable.

Methodology:

Redesign of the existing ElectroGrow reactor to a field capable next generation version to be completed before project start.

Design team at ElectroGrow to monitor, and be prepared to modify, the next generation reactor as necessary during early stages of deployment as well as after feedback from EERC and partners.

Monitoring of progress to be jointly performed by both ElectroGrow and EERC.

Anticipated Results:

Stage 1: to demonstrate that the ElectroGrow new architecture will be able to function in the field over the extremes of summer and winter environments and be able to operate safely at 80% or greater capacity factor i.e. 49000 hours out of each 61320 hours per year.

Stage 2: demonstrate that ElectroGrow new architecture is able to deliver results of at least 500 gallons/12 barrels of oil produced per 10kW operating reactor. Can be the same as stage 1.

Stage 3.1: Demonstrate ElectroGrow functionality at multiple stages in the natural gas production life cycle: at well head, at field collection points pre- cleaning plant, from pipelines. One reactor/gas tankers/NGL tankers per stage test site.

Stage 3.2: further refinement to achieve results on par with laboratory output: 1000 gallons/23.8 barrels of oil produced per 10 kW operating reactor. Can be the same as stages 1 and 2.

Facilities:

Stage 1: ElectroGrow reactor at any location, potentially on site with a partner or at EERC. One standard 16000 gallon tanker of pipeline quality natural gas. One standard 16000 gallon tanker with 3000 gallons of NGLs.

Stage 2: ElectroGrow reactor at any location, potentially on site with a partner or at EERC. One standard 16000 gallon tanker of pipeline quality natural gas. One standard 16000 gallon tanker with 3000 gallons of NGLs.

Stage 3: ElectroGrow reactor per location: well head, field collection point, post-cleaning plant or pipeline. Three standard 16000 gallon tanker of pipeline quality natural gas. Three standard 16000 gallon tanker with 3000 gallons of NGLs.

Stage 4: ElectroGrow reactor at any location, potentially on site with a partner or at EERC. One standard 16000 gallon tanker of pipeline quality natural gas. One standard 16000 gallon tanker with 3000 gallons of NGLs.

Resources:

Physical:

1 ElectroGrow reactor system

1 filled 16000 gallon methane tanker container

1 – 16000 gallon tanker container with 3000 gallons of NGLs

Method to assess progress of methane liquefaction (measure amount of methane consumed and oil producted)

Later stages: sites for natural gas production stage testing

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:

Conversion of methane liquefaction increases the dollar value of the input methane from two to six times or more, according to the EIA: https://www.eia.gov/todayinenergy/detail.php?id=5830
The present ratio is approximately five, based on two dollars per thousand cubic feet (mcf) natural gas price and sixty dollars per barrel oil price, after accounting for the ratio of six mcf equals one barrel of oil in heat content.

Methane liquefaction conversion enables natural gas well owners to have an additional option for offtake of their product.

Methane liquefaction conversion enables greater linkage of the natural gas and oil markets. Historical linkage is low at about 0.25: https://thehill.com/opinion/energy-environment/3659235-what-divergent-crude-oil-and-natural-gas-prices-portend-for-the-eu-and-us/

Methane liquefaction conversion offers new economic opportunities for low production wells, for newly drilled wells still building infrastructure, for seasonal pricing variable offtake and likely other possibilities.

The same core ElectroGrow technology can also be used to potentially convert methane to other useful forms of hydrocarbons such as acetylene or propane.

Why the Project is Needed:

The North Dakota Pipeline Authority director, Justin Kringstad, has predicted a glut of five hundred million to one billion cubic feet of natural gas per day in North Dakota by 2027 – a glut which, due to North Dakota's ground breaking anti-flaring laws, will force reduction in oil production of up to two million barrels per day, which in turn will reduce state tax revenue by one hundred million dollars a year.

Methane liquefaction conversion offers new economic opportunities for low production wells, for newly drilled wells still building infrastructure, for seasonal pricing variance for offtake and likely other possibilities.

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.

Methane liquefaction to oil strategically reduces the North Dakota, Bakken region chokepoint of state level usage and offtake capacity of natural gas by enabling a much wider range of transport for Bakken gas production output due to its conversion to oil form.

Methane liquefaction increases the dollar per unit heat value by 5 times or more – this increases tax revenue.

Methane liquefaction reinforces North Dakota's groundbreaking methane reduction laws and goals by enabling economic utilization of low production wells and by offering another option for pre-infrastructure buildout new wells, as well as offering a method to get economic value out of otherwise flared natural gas.

Methane liquefaction is a groundbreaking technology that will position North Dakota as a leader in natural gas economic development.

If the state is able to support it, the production of methane liquefaction equipment and the development of expertise for deployment will create many job opportunities for North Dakotans.

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.*

Status updates via Zoom and written reports every 2 weeks until the completion of the prototype (start to September 2025)

Major project review in July 2025 (End of primary design, prior to Mockups and Testing stage)

Project review every 2 weeks from July 2025 to September 2025 (Build and completion of system)

Field Testing: Initial 3 weeks on site in North Dakota to oversee the transfer of the ElectroGrow reactor and initial setup for each new stage. (September 2025)

Twice monthly status meetings after the initial setup stage, or more as needed, to monitor progress and make changes in plans or design as necessary. (September 2025 to April 2026)

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.

ElectroGrow field version methane liquefaction development and testing:

1) Mechanical Design: June 2026
2) Electrical Design: July 2026
3) Simulations and Calculations: June 2026
4) Mock-ups and testing: July 2026
5) Completion of Field version: September 2025
6) Commencement of Field testing: September 2025
7) Monthly status updates, performance in field: September 2025 to April 2026

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	$484,466		$207,628	
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 @613 hrs		$101,062		
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			$166,700	
Field Testing EERC	$100,000			

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

Development Labor Expenses consist of the design, development, analysis and testing associated with the development of a field version the existing ElectroGrow methane liquefaction system. This cost is based on meeting the proposed schedule. Changing the schedule to 36 months will reduce the labor cost, but will also result in a much later deployment of methane liquefaction capability at scale i.e. much later than 2027.

Non-Development Labor Expenses are the major hardware components of the proposed ElectroGrow methane to liquefaction 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 liquefaction 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 as well as potential use in conjunction with existing and future propane EOR pilot programs.

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 methane liquefaction 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 methane liquefaction 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 a modification of ElectroGrow reactors and system for methane to propane conversion.

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.