NATURAL GAS CONVERSION TO LIQUID FUELS

Grant Application for the Emerging Energy Technology Fund Grant Program
Submitted to: Alaska Energy Authority

Northern Energy Foundation
Dr. Ron Clark
18160 Shadowbrook Way
Morgan Hill, CA 95037
Rn.clark1@gmail.com
408.510.2666

Project Partners

- University of Alaska Anchorage
- ConocoPhillips

Proposed Project Cost: $940,000
Grant Request: $463,000
Matching Funds Committed: $477,000

Northern Energy Foundation has not submitted a prior Grant application for Alaska programs.
Northern Energy Foundation is an Alaska Nonprofit Corporation, see Appendix 1
Northern Energy Foundation is partnered with UAA, see Appendix 2

SEPTEMBER 3, 2013

This section is non-confidential.

Natural Gas Conversion to Liquid Fuels
Funding request of the Northern Energy Foundation

Project Description and Innovation Our Team, led by Northern Energy Foundation (NEF), an Alaska Nonprofit Corporation, proposes to build and test a laboratory petrochemical reactor that efficiently converts natural gas to liquid fuels via a novel catalysis process. The technology under development leads to an operational system for the conversion of natural gas or shale gas (methane) into a liquid fuel for heating and transportation applications. This is a small, but scalable, conversion system which is ideally suited to select markets, particularly in geographically remote areas with undeveloped natural gas resources. Because the system is modular and skid mounted, it can be transported into remote locations where stranded gas is unused or flared. Vast supplies of shale gas and methane hydrates fall into the category of "stranded" and cannot be brought to market with current technology due to the enormous added cost of a pipeline, liquefaction or other infrastructure impediments encountered in moving the remote gas to a large central petrochemical facilities. The major petroleum companies have not explored the advantages of our innovative process for gas to liquid conversion.

Our hybrid methodology accomplishes the task of conversion into liquid in a unique way, at lower operating temperature using a combination of proprietary methods and catalysis. The process is confidential and is described on pages 3 and 4 of this abstract. Unlike the current Gas-to-Liquid methods which cost $14 B or more, our GTL systems are projected to cost approximately $3 M depending on volume. Current GTL systems employ various *Fischer–Tropsch* processes consisting of a high temperature carbon monoxide method - which has been difficult to reduce in scale, this conversion method is designed from the start to be less complex, more energy efficient, environmentally friendly, and implementable in a small scale, low cost system. In our GTL reactor, methane and another source of inexpensive carbon – such as coke, crushed coal, charcoal, refinery "resid," refinery coke or asphalt are combined and converted efficiently into higher alkanes. The complete system with genset can be trucked to stranded gas sites, arctic clathrate or hydrate sites, or even landfills. Natural gas or shale gas sources which are productive for as short a time frame as a few years become exploitable.

A mixed light naphtha fuel or alternatively, an LP gas for pressurized systems –or an oxygenated clean fuel (which is mostly butanol) can be produced in this process. The light naphthas are the most economical product for cold environments. These have not previously been made efficiently from methane, shale gas, or a hybrid CTL process for a variety of technical reasons related to the complex demands of Fischer-Tropsch and its descendants. Traditional methane conversion processes are complex, due to catalyst deactivation issues. These issues are mitigated with our new process, due to the introduction of a low cost catalyst that functions due to innovative properties of the system.

Our system will reduce environmental impact from both methane and CO_2 sources. Variants of the Fischer-Tropsch (F-T) method require oxygen and in-process combustion to maintain temperature up to 1,400 °C. Toxic emissions are a major problem and new environmental regulations will add more complexity and cost to existing systems.

Our GTL modules use an automated process designed to be mounted as a modular mini-factory that is portable and can be set-up and moved repeatedly during its lifetime. A semi-permanent but fully adequate production facility that can be scaled to meet local supply and demand can be placed in operation within weeks of regulatory approval, thus avoiding the necessity for a gas pipeline or gas storage facilities.

The commercial operation is envisioned as employing factory produced modules to lower cost. Each mini-plant can be designed to produce from 200,000 to 2.5 million gallons of liquid-fuel output per year per skid. Multiple skids can be collocated for larger operations. An estimated cost summary is provided on page 4 based on currently projected numbers with wholesale fuel cost well below $2 gallon.

Contact: Ron Clark: Rn.Clark1@gmail.com 408.510.2666

For end markets, LP gas which is a mixture of pressurized propane and butane can be distributed direct to end users, whereas a mixed fuel product can be sold to local fuel distributors or blenders for an improved "gasohol," to be blended with gasoline in areas where pollution control is important. For rural Alaska, LP gas is a cost effective alternative to heating oil. The light naphthas can be blended in gasoline, or used alone. A representative fuel output of the mixed fuel variety is derived from approximately 45% methane by weight, 35-40% crude carbon and 18-20% oxygen (from H_2O) for the oxygenated fuel. These proportions are variable by design and can be adjusted to provide the desired hydrocarbon products.

The raw material equivalent cost can be as low as 30% of the wholesale value of the output, based on 2013 prices. For instance, a gas site operator should be able to recapture plant construction cost in approximately one year.

Proposed Development During this project, development will be conducted in two locations: at a laboratory in Morgan Hill, CA and at a laboratory in the Engineering Department at UAA. The basic components of an operating unit to test and validate methane conversion will be designed and constructed by the NEF with support by UAA. The test units will be operated by the NEF and UAA with data analysis supported primarily by UAA laboratory equipment. Laboratory methane will be used for initial testing with commercial gas sources used in subsequent tests. A key performance metric is the rate of breakdown of methane and the subsequent equilibrium amounts of higher carbon molecules which are derived from the process denominated by processing time, operating temperature, and power input. A second performance metric is the determination of the control parameters to optimally control the conversion products. The technology is currently at a TRL 2 and will be advanced to TRL 4 by this project. The 12 month schedule and $940 K cost details are shown on page 3. NEF plans matching funds of $477 K and a Grant request of $463K.

ConocoPhillips participates as part of our team to ensure designs and tests support a path to commercialization of the methane conversion capability at a representative commercial deployment site. The project site for field demonstration of the Phase II methane conversion system will be selected by associates at the University of Alaska Anchorage in coordination with NEF and ConocoPhillips. Participants from the University will be involved in ongoing development and data collection.

Project Team Qualifications NEF is led by Dr. Ron Clark and Jones Beene who are co-inventors of the conversion process and have broad background experience in many aspects of industrial processes and scientific innovation. Dr. Clark has a Ph.D. in Solid State Physics and was the Director of Future Concepts for Lockheed Martin Space Systems and Director of the Naval Technology Office at DARPA. Mr. Beene is a technical consultant, former attorney and former polymer engineer (SPE). Also, part of the NEF Team is Dr. Angel Sanjurjo, Director Emeritus of the Materials Research Laboratory at SRI, International with over 30 years of Materials Research. The UAA effort is led by Dr. Aaron Dotson and Dr. Tom Ravens. Dr. Dotson is an Assistant Professor of Environmental Engineering and is the laboratory director. He oversees 6 graduate students with direct process development experience. Dr. Ravens is a Professor of Civil Engineering and Director of the Fluid Mechanics and Hydrokinetics Lab at UAA. Dr. Ravens earned a Ph.D. in Environmental Engineering (MIT) and has been working to develop alternative energy technologies in Alaska for the past 5 years.

Commercialization of Funded Technology This project will develop and validate key performance functionality and design a fractional-scale prototype unit which will be capable of being sited at an appropriate shale gas site as close to Anchorage as possible. Once this conversion process is validated with rigorous laboratory measurements, we plan to seek additional funding to build the field demonstration unit as a path to commercialization. The market potential for this gas conversion capability is estimated to exceed $100 million per year.

Priority This project supports the recommended priority of energy storage. The liquid fuels we produce are much higher energy density than gas, enabling more compact storage, transport, and usage by individuals.

Schedule and Budget The projected schedule for this project is shown in Table I below. We plan to build and test two reactors, leading to a prototype that can be operated in a field test environment.

Natural Gas Coversion to Liquid Fuels Schedule (Months)												
Schedule Item	1	2	3	4	5	6	7	8	9	10	11	12
Complete lab specification and purchase hardware	x											
Complete design of Reactor 1		x										
Complete design of Reactor 2						x						
Conduct testing and analysis										x		
Complete test reports			x	x	x	x	x	x	x	x	x	
Define & design 1/4 scale prototype												x
Project demonstrations						x					x	
Complete & submit documentation												x

Table I. The schedule provides for multiple tests and data analysis periods for 2 existing reactor designs.

The budget for this 12 month project is shown in Table II. The total cost is $922,000 including a matching contribution from NEF of $462,000. For the matching funds, NEF plans to contribute 75% of their labor on this project at a rate of $155 per hour. NEF requests $463,000 from the AEA Grant funds.

Natural Gas Convesion Budget (12months) ($K)	Total	Match	Grant
Test & analysis equipment	$ 75		$ 75
Travel	$ 26		$ 26
Salary	$ 702	$ 477	$ 225
Consultants	$ 25		$ 25
Operations and lab analysis	$ 66	$ -	$ 66
Legal, fees, and admin	$ 46		$ 46
Total	$ 940	$ 477	$ 463

Table II. NEF and UAA are contributing more than 50 % of the total budget.

By signature on this application, I certify that we are complying and will comply with the amount of matching funds being offered.

Ron Clark