Marine Environmental Solution Pre-Combustion Catalyst Injection System Test Project

Diesel Fuel Efficiency and Emissions Reduction for Electrical Generators in Rural Alaska

Project Partners

Venetie Tribal Government • Native Village of Beaver • Venetie Village Council • EmTech NW • Marine Environmental Solutions • Beaver Joint Utilities • Interior Regional Housing Authority • University of Alaska Fairbanks • Yukon River Inter-Tribal Watershed Council

Total Project Cost: $335,747.00
Grant Funds Requested: $286,917.6
Match Committed: $48,830

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Previous Project Title Under Renewable Energy Grant Fund: Ruby Hydrokinetic Construction
Grant #: 2195402
Note: This grant is closed out

1. Project Summary

1(a) Project Description

A recent study completed by Commonwealth North found that nearly 80% of rural communities in Alaska are dependent on diesel to meet their energy needs. A big part of this need is electrical generation. Rural generator sets run 24hrs a day 365 days a year. The Marine Environmental Solutions (MES) Platinum-based Pre-Combustion Catalyst Injection System (PCIS) has been tested on marine diesel engines for propulsion and onboard electric generation. Tests have shown increased fuel efficiency of 5%-10%, cleaner cylinder heads, reduced pistons wear and improved emissions. This proposal will run a thorough test of the PCIS on a rural diesel generator and determine savings from increases in fuel efficiency and lower maintenance costs on the generators.

The Yukon River Inter-Tribal Watershed Council (YRITWC) a consortium of 70 tribes throughout the Yukon River Watershed in Alaska and Canada has researched the company and its claims. After speaking with diesel mechanics and marine operators who have been using the PCIS for over 2 yrs with many benefits and *NO* reported ill effects, the YRITWC has partnered with MES and arranged for a test in 2 rural Alaskan communities, Beaver and Venetie. The YRITWC is also in the process of working with the Gwichyaa Zhee Corp. board in Fort Yukon to test the system on a larger generator set. If Fort Yukon decides they would like to be involved with the project we will move one proposed test site from Beaver to Fort Yukon to test the system on larger generators.

Project staff will install and monitor the PCIS technology on 3 generators in each village during the fall of 2012. State of the art Kral fuel-flow meters (calibrated to .1% accuracy), electrical meters and monitoring equipment will be installed on each generator to continuously log and record the gallons of diesel burned per kWh for 1yr in both of the selected villages. Details on observed changes, installation difficulties and experiences will be logged manually and electronically. Tests on engine oil, engine coolant, smoke opacity, NOx, CO_2 and Diesel Particulates will occur at pre-assigned intervals throughout the test and be conducted by project staff, University of Alaska researchers and independent testing labs. Dr. Rorik Peterson, Mechanical Engineering Professor at UAF, will oversee all testing procedures and data collection. At the conclusion of this study Dr. Peterson will produce an independent report on the test results.

1(b) Project Eligibility

The Marine Environmental Solutions PCIS is a technology that can increase the combustion efficiency of a diesel generator thereby increasing the number of kWhs generated per gallon of diesel. The product improves an existing technology (diesel generator) and has not yet been demonstrated in Alaska on a diesel generator.

1(c) Project Innovation

For those unfamiliar with how a diesel engine works, explaining the concept behind the PCIS will be difficult. Thus, we've provided a basic description of how the engine functions here. Unlike a gas engine, which utilizes a spark plug to ignite gasoline in a cylinder, a diesel engine heats air through intense compression. The heat generated by this compression ignites diesel that is injected into each cylinder. The term "Ignition Lag" refers to the time it takes the fuel –which enters the cylinder at ambient temperature- to heat up to the point of combustion. The best diesel engines are between 45%-55% efficient while many older generators in the state have efficiencies closer to 35%-40%.

The MES, Pre-Combustion Catalyst System is NOT A FUEL ADDITIVE. The system is composed of a 'delivery unit' and replaceable bottles of catalyst. The delivery unit is fitted onto the air intake system of the engine between the air cleaner, and the Turbocharger. The delivery unit "nebulizes" the product –turns the product into a vapor, similar to an inhaler - and injects it into the air-intake of an engine. The engine's air intake system injects the vapor along with the air into each cylinder prior to the injection of fuel in a normal compression cycle. A photo of the system can be seen in **Appendix A** The vapor immediately begins to react with unburned hydrocarbons that are present in the form of soot or un-combusted vapor but the main reaction occurs when the fuel is injected. The Platinum salts in the catalyst break down hydrogen compounds that are present in any normal hydrocarbon chain. This helps some of the longer chains of diesel fuel-hydrocarbons –chains that would not be fully combusted under normal circumstances - become shorter chains that will ignite more completely and at a lower temperature. This

shortens the "ignition lag," which lengthens the period of combustion and allows a more efficient burn of the diesel fuel. In this manner, the catalyst helps the engine reduce energy waste in 2 ways.

1. Excess heat energy normally generated via combustion is transferred into greater mechanical energy
2. Unburned hydrocarbons that normally escape through the stack or accumulate in the engine, creating a need for frequent engine overhauls, are now burned in the cylinder, which further increases mechanical energy AND reduces exhaust emissions

By increasing the volatility of fuel in the cylinder, the engine is able to more efficiently transfer energy from the fuel into mechanical energy. This means we can generate the same amount of power with less fuel.

FUEL EFFICIENCY:

A rural village's generator system is composed of diesel engines that run 24/7/365. As amperage loads on the generator increase or decrease, the engine experiences more or less resistance to create the required power. Think of a bicycle break - the harder you squeeze the more resistance and thus the more amperage. By increasing the available energy in each compression stroke, less fuel needs to be consumed to produce the same amount of work. For example if it takes 7.5 gal/hr to maintain an amperage load of 55%, we may now be able to maintain that same load for 6.95 gal/hr - a 7.3% increase in efficiency. An Economic Model for a single generator engine running only 4000 hours (~1/2 year) in Fort Yukon is available in **Appendix B**.

ENGINE HEALTH:

The more efficient combustion also creates a cleaner burn in the cylinder. In the case of one MES customer, which had the PCIS installed on their large mining trucks, the system increased the time between engine overhauls and oil changes by 15%. Venetie shipped a generator into Fairbanks in 2011 for an overhaul and air freight alone was $13,500 *plus* the cost of the overhaul. Part of the test will be to determine if this product can increase the time between needed engine maintenance. An article in **Appendix C** discusses these advantages.

With 85 separate utilities serving more than 180 communities statewide the age, make and model of generators varies significantly. Although increases in efficiency will vary based on a number of factors, the basic diesel function remains the same - meaning the PCIS can be retrofitted onto any diesel engine. Since the PCIS system has been shown to reduce Diesel particulate matter between 40% -60% and NOx, SOx between 15-25%, an equally important benefit is a reduction in emissions coming from the powerhouse.

1(d) Priority

The PCIS Test Project involves Alaskan residents and organizations including Beaver Village Council, Beaver Joint Utilities, IRHA, Venetie Village Council and the YRITWC. We stand to have a direct and positive impact on the lives of rural Alaskan residents through decreased utility costs and decreased emissions. The UAF Mechanical Engineering dept. is a project partner and will provide an independent assessment. The project is supported with in-kind matching funds from Marine Environmental Services and participating villages. Most importantly, the project has direct applicability to over 200 communities statewide that rely on diesel generators.

2. Technical Validation and Research Methodology:

2(a) Objectives

1. Determine if there is a verifiable, kWh/gal increase in efficiency from the use of the PCIS
2. Determine if the PCIS increases the health of the engine and can lead to increased intervals between engine oil changes and overhauls.
3. Determine is the PCIS is suitable for rural Alaskan generator operators to operate and maintain
4. Determine if the PCIS reduces emissions from a diesel generator

All tests of the PCIS system will be done in the field. The kWh/gal will be evaluated by establishing a baseline data set at different load levels under normal system operations. Data monitoring equipment for the gen-set is included in the project budget. Once the baseline data set is established, the system will be turned on and run for 1 year, with data recording on the load levels and fuel burn. Project staff will visit the sites quarterly to report on the system, note concerns/challenges, work with the operator, perform emissions tests and take Engine coolant and engine oil samples (samples submitted to independent labs).

2(b) Methodology:

Our partner in this project, Marine Environmental Solutions Inc has an established testing methodology used for data collection and verification of their products on different engine styles. The YRITWC has involved the UAF, Mechanical Engineering Department in the study to provide data collection, methods review, project oversight and to write an independent 3rd party report on the test. A brief overview of the methodology is below:

1. During the initial scoping trip, data will be recorded on individual village powerhouses, including historical usage from PCE/operator records. Specs on the generator switch gears and air intake systems will be taken to size monitoring equipment and PCIS system.
2. Data monitoring equipment (load and fuel burn) will be installed to log results on fuel consumption at different village loads for 250-500hrs. Initial samples of village generator coolant and engine oil will be taken. Initial measurements on powerhouse emissions of SOx, NOx, particulates under normal operating load will also be taken. UAF engineering staff will participate. Kral fuel flow meters, calibrated to measure fuel flow to within .1% accuracy will be used for this test. By using state-of the art monitoring equipment, project staff will be able to provide extremely accurate data from inside a village powerhouse. On site fuel flow data will be comparable to data from an engine testing lab.
3. The PCIS system will be installed and begin recording a data set on fuel burn, electric load, catalyst consumed. Project staff will return once/quarter to take additional oil/coolant samples, run emissions test, and evaluate system with village operator.
4. Project manager will stay in weekly communication with the village operator to determine any issues with the system. Project staff will conduct monthly meetings to analyze available data and evaluate results on an on-going basis.
5. The system will run for approx 12 months. Data will be recorded continuously in the generator house.
6. At the conclusion of the test period, UAF staff will complete an independent 3rd party, comprehensive report on PCIS test results. Emissions, engine oil/coolant tests, fuel logs and load data will all be analyzed, compared and evaluated using economic models. Project staff will complete a system training manual for village operators. Project staff will also complete a separate report on the test. Villages will determine if they want to keep the systems. Engine oil and coolant tests will be evaluated to determine if increases in maintenance intervals are possible. Project staff will work with UAF staff to determine the best measure of engine health.

3. Summary of Project Budget and Project Schedule

3(a) Project Budget (detailed cost break-down spreadsheets available upon request)

	Totals grant funds Requested	**Total Match**
Direct Labor and Benefits:	59962.5	0
Equipment	0	0
Materials and Supplies:	5525	0
Contractual Services		
MES	$174,006.00	$48,830.00
UAF	$25,459	0
Construction Services	0	0
Travel	$18,155.00	
Other:	$3810	0
Total Costs	286917.5	48830

Project Match: This is composed of 20 hours of in-kind time from an IRHA electrician (letter of support available) for the installation of the data monitoring system in the switchgear system in each village. Total In-kind from IRHA is $2500. Marine Environmental Solutions has donated an additional $48,830.00 worth of products to use in the test. Should Fort Yukon participate in the study instead of Beaver, an additional $64,915 will be requested in contractual and an additional $16,618 will be provided in Matching Funds.

3(b)Summary of Project budget:

<u>Quarter 1 (Oct-Dec 2012):</u> Initial scoping trip *and* install trip to selected villages, data recording will begin, baseline

data set will be established, first emissions test, first samples oil/coolant will be taken and sent to lab
Quarter 2 (Jan – March 2013) : Quarterly site trip, available data analyzed, emissions, oil/coolant tests will be taken, weekly interviews with generator operator, monthly project staff conferences.
Quarter 3 (April-June 2013): Quarterly site trip, available data analyzed, emissions, oil/coolant tests will be taken, weekly interviews with generator operator, monthly project staff conferences.
Quarter 4 (July-Sept. 2013) : Final Site trip to villages. If conclusive, initial results will be presented to operator owners. System will either be removed or generator operator owner will decide to continue with the PCIS product
Quarter 5 (Sept-Dec 2013) : Final reports and generator operator manual will be completed and submitted to AEA from UAF and Project Staff. Oil and coolant tests will be analyzed to determine if interval between oil/coolant changes can be extended. Villages will determine if they are interested in keeping the system on their generators.

4. Project Team Qualifications

The project team represents a unique blend of field experience, engineering expertise, product development and product testing capabilities. We're confident that we can accurately test the PCIS on a village generator, and show fuel savings and increased engine health. Our Lead Engineer on the project will be Gary Miller- a 32-yr veteran Engineer for General Motors. Gary has directed 2 GM test sites, trained top GM engineering managers and been developing platinum fuel catalysts since 2007. Paul Masson is one of 6-founding partners of Marine Environmental Solutions and is VP of Business Development. Paul has been instrumental in the successes of their installations and thorough data analysis. Ray Emig has been in the engine repair business for the past 30 years since founding *Ray's Chevron* in Juneau in 1982. Ray is an ASE certified master technician and will be a Lead Field Technician on the project. David Pelunis-Messier is the Energy Director for the YRITWC and will be the official project manager for the PCIS test project. Dave has been managing rural Energy projects throughout the state since 2009 and has developed a network of partners in rural communities, state organizations, local non-profits and private entities. Rorik Peterson Ph.D., Assistant Professor in the Mechanical Engineering Department at UAF will be the lead researcher for the project. Dr. Peterson received his Ph.D. in Chemical Engineering in 1999 at the University of Colorado, Bolder. Most recently Rorik has been involved as a co-investigator on a Department of Energy/EPSCoR project investigating wind-diesel hybrid systems in rural Alaska.

5. Discussion of Commercialization of funded technology

There are many "snake oil" products on the market that claim to "increase fuel efficiency." This PCIS is not such a product. Notable customers include: F/V Kodiak (Deadliest Catch) and the M/V Sea Lion (National Geographics Research Vessel) and a list of Bering Sea Fishing Vessels. There is a large potential for savings in both fuel reduction and engine maintenance costs on generator systems in rural Alaska. The product is already available for sale on diesel engines but has not been tested on a village generator. Without a thorough test of the product by an independent 3rd party, generator owners are reluctant to try the system. By working with UAF to conduct a thorough test of the technology we will be able to showcase the product's cost-effectiveness and verify manufacturer claims on emission reductions. **Appendices D and E** have documentation of some of the work and projects that MES has been involved with.

The product manufacturer has an established Alaskan distributor working with marine engines (EmTech NW). It will be simple to include markets in rural Alaskan villages. Across Alaska there are more than 200 rural villages operating off diesel generators, in 2010 these generators consumed 27,597,323 million gallons of diesel to produce electricity. The state of Alaska funded $37,660,000 in its appropriations budget to pay for the Power Cost Equalization Program, money that ultimately went to pay for diesel fuel. If this study leads to the widespread application of this system, the potential exists for a reduction in fuel consumption of 1.37 – 2.75 million gal/yr, an average savings of $5.48- $11 million annually (at $4/gal).

6. Signed Applicant Certification

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

David Pelunis-Messier	Energy Project Manager Title:	March 9 2012 Date: