Delta T Wood Stove Generator Project

AEA-12-047 Emerging Energy Technology Fund

1. Project Title: Delta T Wood Stove Generator Project

2. Applicant Contact Information:

Alaska Dynamics
Theo Graber, President, Project Manager
433 M. St. Anchorage, AK 99501
Ph. 907.748.5292
alaskadynamics@gmail.com

Jon Bittner, Principal Investigator
4031 Woronzof Dr, Anchorage, AK 99517
Ph. 907.529.1103
JonSBittner@gmail.com

3. Partners:

Shiva Hullavarad, PhD, MBA, Technical Advisor
University of Alaska Fairbanks
Advanced Materials Group
Institute of Northern Engineering
3330 Industrial Avenue, Fairbanks, Alaska 99701
Box 758090, Fairbanks, Alaska, 99775-8090
Email: sshullavarad@alaska.edu
Ph. 907.455.2017 FAX 907.455.2019

4. Total Project Cost; $410,400
Grant Funds Requested: $291,900
Match Committed: $118,500

5. Previous project/application title(s) and/or number(s) for grants from the Renewable Energy Fund or Denali Commission Emerging Energy Technology Grant program:
None

6. Previous Project title(s) for abstracts submitted tot he Emerging Energy Technology Fund, if applicable:
None

1. Project Summary

a. Project Description: The Delta T Wood Stove Generator is a self contained thermal differential generator that replaces the first piece of stove pipe on a wood stove and generates electrical power whenever the stove is running. Installation is simple and there are few moving parts requiring only minimal maintenance. The Delta T Wood Stove Generator Project will prototype, test, refine, and bring the product to market.

The project will build and extensively test two generations of prototypes of the Delta T Wood Stove Generator. First generation prototypes will be built and tested in-house at Alaska Dynamics. The data collected during testing will be used to refine the design. Second generation prototypes incorporating the first generation design changes will be built by Alaska Dynamics and tested in the field in a variety of environments in Alaska. The data collected during field testing will be used to further refine the final design. The goal is to bring the product to market at the end of the two year project. The Delta T Wood Stove Generator will supply wood heated homes in Alaska with a cheap supplemental energy source increasing energy independence and reducing power consumption from non-renewable sources.

b. Project Eligibility: The Delta T Wood Stove Generator Project satisfies all three criteria of AS 42.45.375(c). The proven core technology of the product has existed for many years but will be deployed in the generator in a novel manner increasing wood combustion efficiency and generating power thereby qualifying as an *emerging method of conserving energy* (1). It *has not previously been demonstrated in the state* (3) and it *improves an existing technology*, the wood stove, by increasing wood combustion efficiency, reducing emissions, and generating power (2).

The Delta T Wood Stove Generator satisfies 3AAC 107.715 (1), above. 3AAC 107.715 (2), it *enhances the efficient use of energy in the state* by generating power from wood combustion and reducing wood smoke emissions. Under AS42.45.375(j)(2) as an *"energy technology"* it *enhances an available energy source*, wood, by generating power during combustion. The device *increases energy efficiency* by generating power during combustion as well as taking advantage of an advanced catalytic converter that increases combustion efficiency and *reduces negative energy-related environmental effects* by reducing combustion emissions. The Delta T Wood Stove Generator is an *"energy technology"* that *relates to renewable sources of energy*, wood, and promotes the conservation of energy by reducing power consumption from non-renewable energy sources.

Section 4.2 of this RFA is satisfied through the criteria listed above as well as the following. The project has an extremely high expectation of being brought to market in fewer than five years as it will be ready to bring to market at the end of the two year grant period.

The preliminary design is complete and the components involved are either easily fabricated or existing commercialized technologies. The TRL of the project will progress from a TRL 4 through to a TRL 9 as it is deployed in field conditions and readied for production.

c. Project Innovation: The Delta T Wood Stove Generator will increase the performance of the wood stoves it is installed on in four ways. 1.) The thermoelectric modules incorporated in the device generate power from the heat differential between the hot gasses exiting the stove and the air of the room. 2.) The room air circulates past the heat sinks on the outer shell of the device increasing the heating efficiency of the stove. 3. & 4.) The advanced catalytic converter employed in the device to increase the temperature differential operates by performing a secondary combustion of the flue gasses resulting in a dramatic increase in combustion efficiency and a reduction in emissions. The Delta T Wood Stove Generator will also provide a unique level of energy independence for its users.

The device is built into and around a standard 24" long piece of stainless steel stove pipe and is 12" in diameter at its widest point on the 6" model. It is designed to replace the first section of stove pipe on a wood stove. Installation is as simple as removing the old stove pipe section, installing the Delta T Wood Stove Generator in its place, and connecting the power leads.

The unit consists of three shells. There are two paths for the flue gas to pass through the generator, one within the other, controlled by a temperature activated automatic diverter. The flue gas may pass either

through the catalytic converter in the center of the generator or through a bypass route between the first and second shells depending on the temperature of the flue gas. Catalytic converters require hot flue gas to initiate the secondary combustion process, known as "light off". The automatic diverter is designed to divert smoke around the cat during startup and reloading of the wood stove when the flue gas temperature is low and the potential for carbon build up inside the catalytic converter is high. Once the flue gas approaches light off temperature, the diverter diverts the flue gas into the catalytic converter, warming it to operating temperature. Once the secondary combustion reaction is initiated it will sustain itself until it runs out of fuel. A wood stove operating in this mode can enjoy extended burn times and high heat output as well as significantly reduced emissions. The main design flaw of existing catalytic wood stoves is their reliance on the user to switch the flue gas diverter and consequently they suffer from inefficient operation and carbon buildup in the catalytic converter. The Delta T Wood Stove Generator avoids these problems with its automatic diverter. The design of the heat sink coupling the catalytic converter and the hot side of the thermoelectric modules conducts heat to generate power in either catalytic converter or bypass mode.

Around the outside of the second shell of the device is a ring of high output, high temperature thermoelectric modules coupled with heat sinks to the catalytic converter inside. A 5mm aerogel insulation blanket covers the second shell to maximize the thermal differential and minimize heat loss between the inside and outside of the second shell. A third outer shell directs room temperature air past a ring of pin fin heat sinks on the outer surface of the thermoelectric modules to cool them, maintaining the temperature differential across the modules and insuring effective power generation.

A small control box is mounted on the outer shell incorporating a simple temperature control and actuator for the diverter, a temperature and output voltage display, and a micro inverter. In both on-grid and off-grid models the DC power generated by the thermoelectric modules is converted to AC before it leaves the generator to minimize line losses during transmission. Off-grid models will be equipped with a voltage regulator to charge a house storage battery. On-grid models will be equipped with a commercially available UL listed circuit protector allowing the unit to supply power by being plugged directly into any power outlet in the home.

d. Priority: The Delta T Wood Stove Generator Project addresses the priority considerations in the following ways.

1.) Alaska Dynamics is an Alaskan owned and operated company.
2.) The project will cooperate with the University of Alaska Fairbanks with Dr. Shiva Hullavarad as technical advisor.
3.) The project is supported by matching funds. Alaska Dynamics is contributing $30,000 in cash and $76,000 of in-kind labor. AMEP is contributing $12,500 of in-kind services.
4.) The potential market within the state is widespread. The Delta T Wood Stove Generator will be desirable for both on and off-grid installations.

"An estimated 8,632 homes in Alaska use wood as their primary source of heat." *Pg. 16, USDA General Technical Report PNW-GTR-827, August 2010*

2. Technology Validation and Research Methodology

a. Objectives: Safety and effective power generation are the two main objectives of the technological validation process for this project. The basic technology the device utilizes, wood stoves, thermoelectric modules, and catalytic converters, are proven technologies. In order for the Delta T Wood Stove Generator to safely and effectively generate power the design of the device must insure that the components operate efficiently within their design parameters. If these criteria are met, the device will safely and effectively generate power.

Design specification parameters have been identified for each component of the Delta T Wood Stove Generator. During testing sensor arrays will be installed in the prototypes to generate an extensive operational data set. This data set will be stored and analyzed to evaluate if each subsystem of the device is operating within parameters. Design changes will be made to correct any deviations.

b. Methodology:

Two generations of prototypes will be built by Alaska Dynamics and fitted with an array of temperature and gas sensors to collect operational data. The first generation prototypes will be tested in-house on wood stoves in a controlled environment at the Alaska Dynamics facility. Operational data will be collected and analyzed during testing and design changes made where operation falls outside design parameters. Second generation prototypes with remote data logging capability will be built by Alaska Dynamics incorporating the design changes from the first generation and field tested on wood stoves in a variety of potential installation environments in Alaska. The final design will be further refined based on analysis of the field testing data.

Design specification parameters for the catalytic converter:

1.) The catalytic converter temperature must be high enough during operation for the secondary combustion reaction to light off, between 400°F and 600°F.

Flue gas temperatures will be monitored above and below the catalytic converter to verify efficient operation. The design will be modified if necessary to insure the catalytic converter is supplied with sufficiently hot exhaust gas to initiate and maintain the secondary combustion reaction.

2.) The diverter system must reliably divert flue gas around the catalytic converter below the light off threshold, between 400°F and 600°F, and into it above that threshold.

The set points at which the diverter opens and closes will be established for the device. Verification of efficient catalytic converter operation will be determined at different diverter settings based on temperature and emissions data. The diverter settings will be adjusted until optimum conditions are maintained.

The reliable mechanical operation of the diverter will be tested by repeated cycling under a variety of conditions. The diverter system will then be examined for wear or malfunction. Any inadequacies in the design will be adjusted or strengthened.

Design specification parameters for the thermoelectric modules:

1.) The temperature differential between the two sides of the thermoelectric module must be as great as possible without exceeding the design tolerance of the module, about 600°F on the hot side.

Effective thermal coupling must be achieved between the hot side of the thermoelectric modules and the flue gasses. Temperature at the catalytic converter and the hot side of the thermoelectric modules will be measured. The heat sinks coupling the hot side of the thermoelectric modules with the catalytic converter will be modified if necessary to insure efficient heat transfer to the module without exceeding its temperature tolerance.

Efficient cooling must occur on the outer, cold side, of the thermoelectric module. The temperature of the cooling air and the cold side of the thermoelectric module will be measured. The cooling air circulation will be increased and or the heat sink modified if more efficient cooling is required.

2.) The insulation blanket around the second shell must efficiently block heat transfer to the outer cooling shell. Temperatures will be monitored on either side of the insulation blanket. If the thermal bleed through is too high the insulation material thickness will be increased.

Design specification parameters for the device housing:

1.) The device must not experience excessive carbon buildup. Carbon deposits will be monitored throughout the testing process and design changes made if they become excessive.

2.) The device must be gas tight and well constructed. The device will be monitored during operation to check for gas leaks and sound construction.

3. Summary of Project Schedule and Summary of Project Budget

Summary Project Schedule:

1st Quarter: Material and equipment purchase. Installation of test woodstove. First generation prototype construction.

2nd Quarter: First generation prototype testing, data collection, and analysis.

3rd Quarter: First generation design changes incorporated. Testing and data analysis continues.

4th Quarter: Second generation prototype construction. UL approval process initiated.
5th Quarter: Second generation prototype field testing initiated. Begin remote data collection.
6th Quarter: Second generation data analyzed and final design changes identified.
7th Quarter: Final design changes implemented. Field testing continues.
8th Quarter: Preparation for production. UL approval finalized.

Summary Project Budget:

	EETF Grant Funds	Grantee Matching Funds	Source of Matching Funds	Totals
Direct labor and benefits	$70,000	$76,000	In Kind Match	$146,000
Travel & Per Diem	$10,000			$10,000
Equipment	$74,700	$10,000	Cash Match	$84,700
Materials & Supplies	$65,200	$10,000	Cash Match	$75,200
Contractual Services	$10,000	$12,500	In Kind Match	$22,500
Construction Services				$0
Other Direct Costs	$62,000	$10,000	Cash Match	$72,000
Totals	**$291,900**	**$118,500**	Total match: 28%	**$410,400**

4. Project Team Qualifications:

Theo Graber, Project Manager. Theo Graber will be responsible for project management as well as design and production. As the inventor of the Delta T Wood Stove Generator, Theo, will be responsible for the prototyping, testing, and design refinement of the device as well as managing the operation of the project under the grant.

Theo has sixteen years of experience in manufacturing. His relevant skills include previous product development project management in Alaska, 3D CAD design and animation, graphic design, precision machining, welding, electronics design and fabrication, and a lifelong passion for inventing.

Jonathan Bittner, Principal Investigator. Jon will be responsible for overseeing the collection and management of the operational data set during technological validation. He will ensure valid scientific methods are employed to maintain the accuracy and relevance of the information collected. Jon will work closely with Theo Graber during the analysis and design refinement portion of the project.

Jon holds a Bachelor of Science in Geology. He has spent several years as a field geologist/GIS specialist and project geologist. He is currently serving as the Business and Economic Development Director for the Anchorage Economic Development Corporation where he specializes in business development. Jon also spent several years as a legislative aide for the Alaska Legislature. John has an abiding devotion to science and entrepreneurship.

5. **Discussion of Commercialization of Funded Technology**

The commercialization of the unique application of technology the Delta T Wood Stove Generator represents is as yet undeveloped. The Delta T Wood Stove Generator will be demonstrated, manufactured, and marketed to wood heated homes across Alaska well within five years.

The market for this device will be the almost 9000 homes in Alaska that rely primarily on wood to heat their homes as well as thousands more for which wood is a supplementary heat source. By providing a supplementary energy source from renewable fuels such as wood, the Delta T Wood Stove Generator will help reduce dependence on energy generated by non-renewable resources.

The Delta T Wood Stove Generator generates power at the individual user level, helping to address Alaska's energy needs from the bottom up. The device reduces energy needed to be purchased by home owners instead of creating energy for purchase.

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