AEA Emerging Energy Technology Grant Application AEA-12-047

Project Title: **Micro-CHP Development with the Infinia CHP System in NW Alaska**

Applicant Contact Information: **NANA Regional Corporation**
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Project Partners: **WH Pacific**
Infinia Corporation

Total Project Cost: $375,000
Grant Funds Requested: $305,000
Match Committed: $70,000

Previous REF or EETF Grants: None

Previous EETF Abstracts Submitted: **Dual Fuel Micro-CHP Development with the Infinia CHP System; Underground Coal Gasification**

Project Summary

Project Description: NANA Regional Corporation (NRC) will team with WHPacific, and Infinia Corporation to demonstrate the technical feasibility and energy and cost savings provided by a prototype Infinia Combined Heat and Power (ICHP) system in Arctic applications. ICHP holds the potential to provide significant benefits in Alaska. NRC identified the Infinia ICHP system during an energy technology screening exercise commissioned by NRC to identify promising energy technologies in the pre-commercial phase from July-November of 2010[1]. Please refer to NANA's web-site for the results of this screening.

ICHP promises high efficiency and flexibility of application and, notably, is a solution readily scalable to meet the energy needs of a wide range of residential and commercial Alaskan buildings. ICHP provides both base-load and backup power functions while also meeting hot water needs with no additional fuel consumption. ICHP installs without major modification into existing indoor or outdoor structures. It can also be utilized as a self-contained and portable system. Though we propose to evaluate its use with propane, ICHP can be adapted to use a range of other locally available variable caloric gaseous fuels such natural gas and biogas. For example, the biogas generated from the previously funded EETG project 'Pshychrophiles for Generating Heating Gas' could be implemented in the Infinia ICHP system. Installation sizes can range from the 2.7 kW demonstration systems described here to modular megawatts. This technology has particular relevance to the Alaska Natural Gas Development Authority and its desire to develop a propane production facility in Alaska and ship propane to rural communities. The leadership at ANGDA will be contacted during the full proposal phase for their support.

The ICHP system is based on Infinia's long-life Stirling engine technology suitable for remote power generation, simultaneously producing 2.7 5kW of power and approximately 7 kW of thermal energy. We project that one 2.7 kW ICHP system running full time will deliver about 66 kWh of electrical energy and 600,000 BTU of thermal energy per day, requiring only about 12 gal/day of propane. We will monitor performance of the ICHP unit to assess electric power and thermal energy produced relative to fuel consumed. We will evaluate and document energy savings relative to the cost of supplying the same energy by conventional means. We also will document CHP operational availability and maintenance or repair history. NRC and Infinia will jointly address regulatory issues, with Infinia focused on providing technical solutions such as anti-islanding circuitry suitable for grid interface. NRC will work with appropriate local and state authorities to ensure that equipment satisfies all safety and interconnect requirements.

After the ICHP system has been reviewed and evaluated by WHPacific, a deployable unit will be placed in one of these village facilities, with the objective of saving heating fuel and power costs over a 10-20 yr timeframe. The ICHP unit would be monitored for one year at a facility to be determined by NRC.

We performed a simple, high level efficiency analysis for this abstract. Assuming the proposed ICHP performs as intended (66kWh and 600,000BTU for 12 gal of propane) it appears to be an attractive technology option for rural Alaska. For this unit the thermal efficiency for power is about 21%. If added, the heating feature of 600,000BTU, which is equivalent to about 5 gallons of diesel for a boiler with an 85% efficiency, the performance of the system shows promise for deployment in the NANA Region. This will be further refined in the full proposal.

The initial fuel to be investigated is propane, given its wide use in heating. The option exists to expand the capabilities of the system to burn variable caloric gases. This involves sensors upstream and downstream of the burner and a control protocol on the burner blower and gas regulators.

Project Eligibility: The proposed technology qualifies as an emerging energy technology, because it captures the waste heat from the cold side of the Stirling engine and uses it to provide needed water heating and power, simultaneously.

The proposed project meets all of the EETF's eligibility criteria:

- It tests an emerging energy technology;
- It improves existing energy technologies;

[1] Please refer to (www.nana.com/regional/resources/maps/) for screening study, entitled Alternative Energy Opportunities Assessment.

- It tests a technology that has never been deployed on an Alaskan village power system.

We estimate the current technology readiness level at TRL 5-6.

Project Innovation: In the face of rising energy costs and the cost of fuel in particular, rural Alaskan and NANA region communities must find new ways to generate and utilize energy more efficiently. In addition, to be most relevant in rural Alaska, a new energy technology must present an acceptable upfront capital investment, be simple to operate, be highly reliable, address both heating and power, have low operating and maintenance costs, and be scalable. The ICHP technology described in this proposal hits all of these requirements, as it promises to utilize fuels more efficiently, has a has a relatively low capital and operating cost, and is compact, scalable, and uniquely reliable. The technical concept behind the CHP project is relatively simple, straightforward and easy to implement: capture the waste heat from the cold side of the Stirling engine and use it to provide needed water heating and power, simultaneously.

WHPacific and NRC have partnered with Infinia Corporation on this proposed project. Infinia has 25 years of experience developing long-life, low maintenance, Free-Piston Stirling Engines (FPSEs). Infinia has successfully commercialized a 3-kW concentrated solar power engine/alternator assembly called PowerDish™, and the Stirling engine core of this will be central to this proposal. To support its product development and commercialization efforts, Infinia has raised investments from, among others, GLG, EQUUS Total Return, Inc., Paul Allen's Vulcan Capital, and Bill Gross' Idealab

The Infinia FPSE is substantively distinct from traditional Stirling engines. Traditional kinematic Stirling engines extract power from the Stirling cycle via mechanical linkages. They are complicated, and expensive to build and operate. They require lubricated seals and bearings that restrict performance, reduce reliability and limit useful life. In addition, power output is difficult to modulate. In contrast, Infinia's FPSE Infinia's design has a simple mechanical configuration and delivers a highly efficient, low- to no-maintenance product. It has an independently mounted power piston that is directly coupled to a linear alternator, and uses virtually infinite-life flexure bearings and clearance seals that require no lubricants of any kind. Power can be varied over a wide range of output levels. And since the Infinia engine is actually a complete generator with integral electric power generation, the Infinia's FPSE has a lower capital cost than a traditional Striling engine with add-on alternator component. In sum, Infinia's FPSE - Is fuel efficient with multi-fuel flexibility; Is very quiet in operation compared to existing diesel gen-sets; Is highly reliable, long-lived, and maintenance-free (min 6,000 hr system life); Has a Low life-cycle cost; Has reduced logistics burden; Produces high quality DC and AC output; Can conveniently capture all of the 'waste' heat in CHP mode.

Priority

Addressing thermal energy needs is a large challenge to overcome in remote power systems of Alaska and successful implementation of this technology will enable lower overall energy costs. There is currently a commitment of $70,000 in cost share for this project which equates to 21% of the project budget. $30,000 is committed by NANA Regional Corporation and $40,000 is committed by Infinia showing equal commitment to the development of this project.

Technology Validation and Research Methodology

a) **Objectives**: The overall project objective is to install, operate and demonstrate the comparative energy efficiency of a prototype Infinia Combined Heat and Power (ICHP) System in Alaska.

b) **Methodology:** The objective will be achieved by: 1) Identification of CHP design needs for the rural AK marketplace 2); Modeling of the CHP needs for a rural AK prototype; 3) Development of a proof of concept design; 4) Assessing the feasibility of integrating system in more buildings. There will be no special permitting needs associated with the deployment of the ICHP system- aside from those permits associated with new building construction and modification in rural Alaska.

Summary of Project Schedule and Project Budget

The project will utilize a phased approach:
Phase One. Phase one will include a feasibility study which analyzes the market potential for this existing technology. This phase includes a Go/No-Go decision point for the project and a decision regarding burner capabilities. **Phase Two** involved the development of a prototype unit. **Phase Three** include testing at ACEP's Hybrid Application Laboratory. **Phase Four** involves installation of a unit in a NANA community building.

		Months After Contract Award																				
Task	**Phase**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21-24**
Technology Evaluation Development	Phase 1																					
Infinia ICHP Conceptual Design	Phase 1																					
Feasibility and Market Analysis Report	Phase 1																					
Prototype Development of Propane Burner	Phase 2																					
Prototype Development of Multi-Fuel Burner	Phase 2																					
Testing at ACEP including Shipping	Phase 3																					
Installation of System in NANA Community Building	Phase 4																					
System Analysis and Final Report	Phase 4																					

Project Match: NRC will be providing project match by providing program management, space and design considerations to accommodate the engineering needs of the ICHP unit at its community facilities; program management support; and non-collection of NRC's in-direct rate could also be considered. NRC would not collect an in-kind rate associated with managing this grant. Our preliminary project match, between Infinia and NRC is estimated at $70,000 which is 19% of the project total.

Task Code	Task Description	Total Cost	Infinia Match Funds	NRC Match Funds	Grant Request
100	Technology Evaluation Development	$ 10,000		$ 1,000	$ 9,000
200	Infinia ICHP Conceptual Design	$ 80,000		$ 8,000	$ 72,000
300	Feasibility and Market Analysis Report	$ 20,000		$ 2,000	$ 18,000
400	Prototype Development of Propane Burner	$ 100,000	$ 40,000	$ 10,000	$ 50,000
500	Prototype Development of Multi-Fuel Burner	$ 75,000			$ 75,000
600	Testing at ACEP including Shipping	$ 15,000		$ 1,500	$ 13,500
700	Installation of System in NANA Community Building	$ 20,000		$ 2,000	$ 18,000
800	System Analysis and Final Report	$ 55,000		$ 5,500	$ 49,500
	Total Cost	**$ 375,000**	**$ 40,000**	**$ 30,000**	**$ 305,000**

Project Qualifications

NANA Regional Corporation- Applicant. NRC (www.nana.com/regional/) has significant experience in resource development, rural development, and deploying appropriate technologies in rural Alaska. As the parent corporation of over 40 subsidiaries, many of them working in the technology arena, NRC understands and has experience in deploying appropriate technology. Please refer to our proof of eligibility attached.

WHPacific- Engineering and Project Management. WHPacific (www.whpacific.com/) is a multi-disciplined architecture and engineering company, with specialties in energy, building engineering, and architecture. Jay Hermanson, Energy Manager, and Distributed Energy Specialist, Katherine Keith, will provide the project management and engineering support. WHPacific's specialty is remote and rural infrastructure and rural energy. WHPacific's experience as a technology integrator can be leveraged with our operations in NW Alaska.

Infinia Corporation- Technology Provider. Infinia (www.infiniacorp.com/) brings over 25 years of free-piston Stirling engine experience to the team (44 years including predecessor organizations McDonnell Douglas and the University of Washington). Infinia focuses mainly on the commercialization of dish/Stirling solar applications (PowerDish™) and leverages experience in developing and commercializing a product using a supply chain within the U.S. automotive industry. Infinia maintains focus on Stirling engine RD&D with concentration on 5 markets: generators, combined heat and power (microCHP and CHP), coolers, cryocoolers, and thermal energy storage (TES). Infinia headquarters include a 29,000 ft^2 purpose-built facility that meets all development needs and a nearby 30,000 ft^2 production facility that can produce 100 mass-market 3-kW engines in 6 weeks.

Discussion of Commercialization of Funded Technology

Potential Market Defined: While there are many market opportunities for the Infinia ICHP outside of Alaska, we have segmented the market into a rural and remote power deployment in Alaska. Target clients could include rural households, rural school districts, municipalities, the Alaska National Guard, remote resource development camps, Tribal Councils, Village Corporations, and other entities living and performing work in rural Alaska. The ICHP could complement rural cooperatives by allowing these entities to scale up on combined heat and power approach without full construction of a complex bulk fuel and power system. Other ICHP users could include individual households and commercial and government building owners in rural cold climate regions dependent on the use of diesel, fuel oil or propane or natural gas for heating and electrical power generation.

Potential Market Size. AEA estimated in 2004 that 70 percent of rural Alaska communities should be able to make cost effective use of combined heat and power (CHP) systems. There are about 230,000 households in Alaska, about 70,000 of them rural. Accordingly, seventy percent of rural households, or about 49,000, could make cost effective use of CHP. Commercial and government buildings add to the potential installed base for CHP. At a projected (assuming mass-production) equipment cost of $10,000 per 3 kW ICHP, the potential market based on these assumptions in Alaska alone would be about $400 million range.

Potential Public Benefit. The public benefit to consider these ICHP units is self-evident. By providing a scalable CHP unit particularly adapted to rural Alaska can assist rural communities with adapting to the high costs of energy. Currently, there is not a viable, integrated CHP unit that can serve a micro-scale application for rural Alaskans. By providing a flex-fuel option for a CHP unit, this will also assist with energy security at the village level in the case of bulk fuel disruption. Last year the community of Ambler had been with-out fuel for over 3 weeks and had been flying-in fuel in small increments.

In summary, the economic public benefits of the ICHP technology include:

- Lower overall energy costs associated with providing power and heating in rural Alaska.
- Decreased reliance on diesel fuel.
- Increased diversity of fuel sources, enhancing reliability and safety of remote power and heating.
- Deployment of *distributed* energy technology, decreasing dependence on centralized power facilities, lowering public exposure to the dangers and costs associated with the failure of such systems.
- Enhanced technology training and employment opportunities in the rural villages.

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.

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Lance Miller
Vice President, Resources
NANA Regional Corporation

Appendices include Letters of Support, Resumes, and Proof of Eligibility