Alaska Energy Authority Emerging Energy Technology Fund Grant Application

Project Title: **Waste Heat Home Power System (WHHPS)**

Contact Information: James Foster
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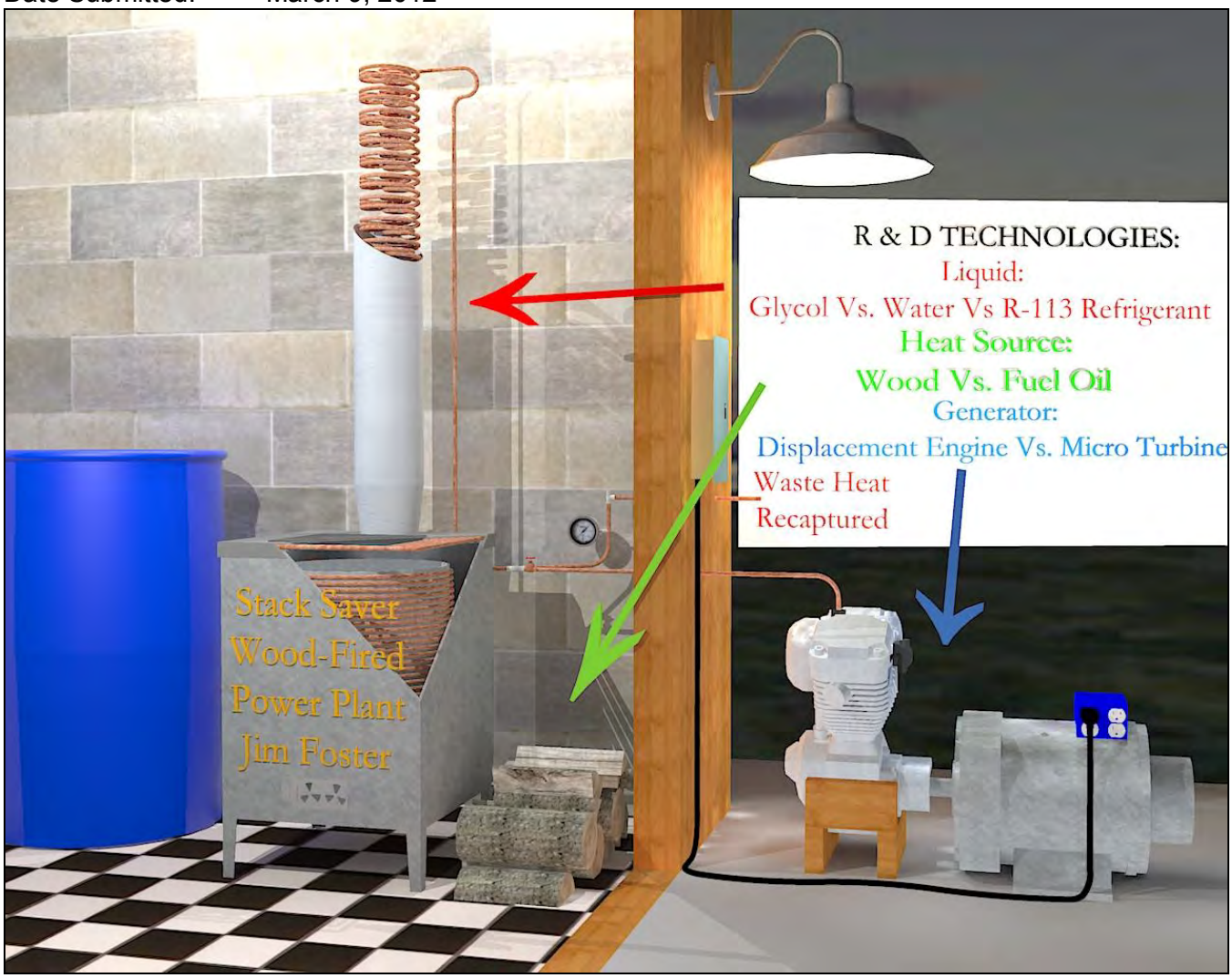
Partners: University of Alaska Anchorage (UAA)
Alaska Manufacturing Extension Partnership (AMEP)

Total Project Costs: $174,750 grant funds requested + $91,400 in-kind match committed

Previous Grants: None
Previous EETF: None
Date Submitted: March 9, 2012



1. Project Summary

A. Project Description

The Waste Heat Home Power System (WHHPS) is focused on utilizing the waste heat from a wood stove or oil-fired stove to run an electrical generator. This project has the potential to provide the electrical amenities of city life anywhere there is a heat source. The WHHPS stack exhaust insert contains piping with expandable liquids which create mechanical energy when heated. This energy is used to power an engine and generate electricity.

This demonstration project will test the various combinations of heat source, liquids and mechanical energy technologies to determine the most efficient waste heat home power system for market consumption.

B. Project Eligibility

A prototype of WHHPS currently exists in Mr. Foster's home using the following technology combination: wood stove, H_2O, a displacement engine, and a generator. This prototype is fully functional, currently provides electricity when operational, and three potential customers have already asked to purchase a unit. As such, this project meets AEA's eligibility requirements.

Once the optimal combination is identified, Alaska Manufacturing Extension Partnership (AMEP) will assist Mr. Foster with developing a commercialization plan, seek investment and distribution partners, and assist with manufacturing requirements. It is expected that this product can be taken to market in less than three years.

C. Project Innovation

The WHHPS is a waste heat recovery unit that uses liquids with low boiling points and high expansion rates coupled with a heat source to produce a rate flow of gas with a variable pressure and volume. This gas pressure is harnessed as mechanical energy by the use of a displacement engine with generator or a micro turbine. The liquid with a low boiling point and high expansion rate leaves the displacement engine or turbine out the exhaust manifold and is used to heat water in the hot water tank. Next, the gas travels through an air cooled radiator leaving its heat for household heat and gets condensed back to its liquid form for injection again into the WHHPS where the process starts all over again.

This technology is similar to a residential scale steam engine generator.

D. Priority

- The WHHPS inventor, James Foster, is an Alaskan resident and a tribal member of the Naknek Village Council. Mr. Foster spent most of his younger years at Honolulu Creek (mile 177 George Parks Hwy.) and continues to embrace his heritage.
- Mr. Foster is currently a student at University of Alaska Anchorage is working closely with Associate Professor of Engineering, Larry Fosters, PhD and Jennifer Brock, PE to conduct this demonstration product.
- Mr. Foster is providing his work shop and the existing prototype equipment as an "in-kind" resource to this project. AMEP's match will be in the form of staff labor at AMEP's standard rate of $100 per hour, documented by time cards with hours billed to project.
- All rural Alaskan homes are either heated by wood stove or heating oil stove; therefore, most rural homes could augment their electrical consumption with the HPS.

2. Technology Validation and Research Methodology

A. Objectives/Hypothesis

A remote rural home can use waste heat to create electricity and reduce the dependence on gas-powered electricity generation.

This power system is based on three separate technologies:

- Heat Source: wood stove and heating oil stove
- Liquids: H_2O, R-113, Glycol + H_2O
- Mechanical Energy: Displacement Engine + Generator (DC or AC), Micro Turbine

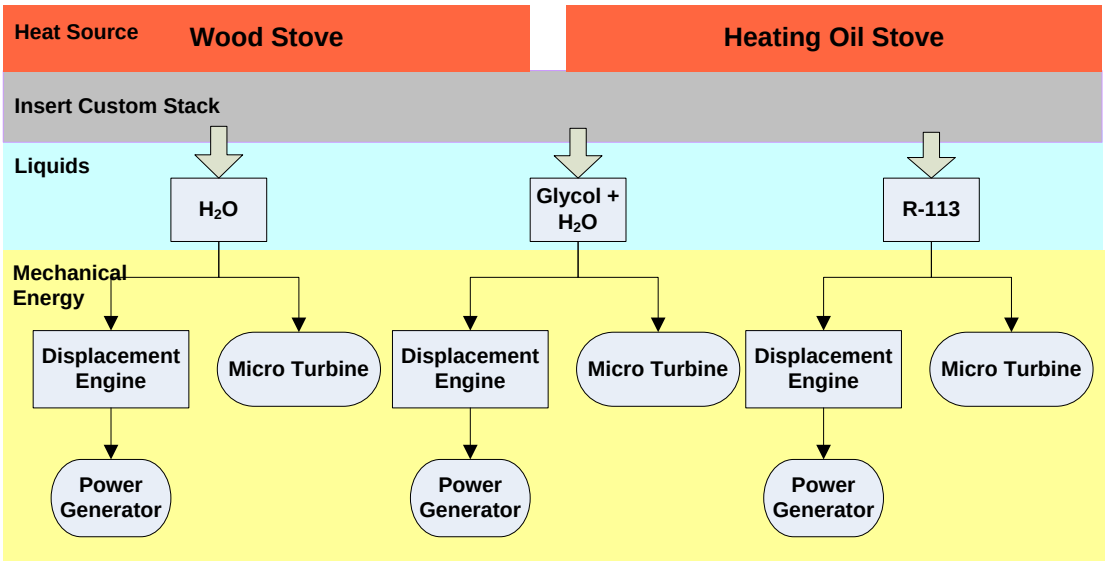
This demonstration project will test the combinations of these technologies to determine optimal, acceptable and ineffective solutions.

B. Methodology

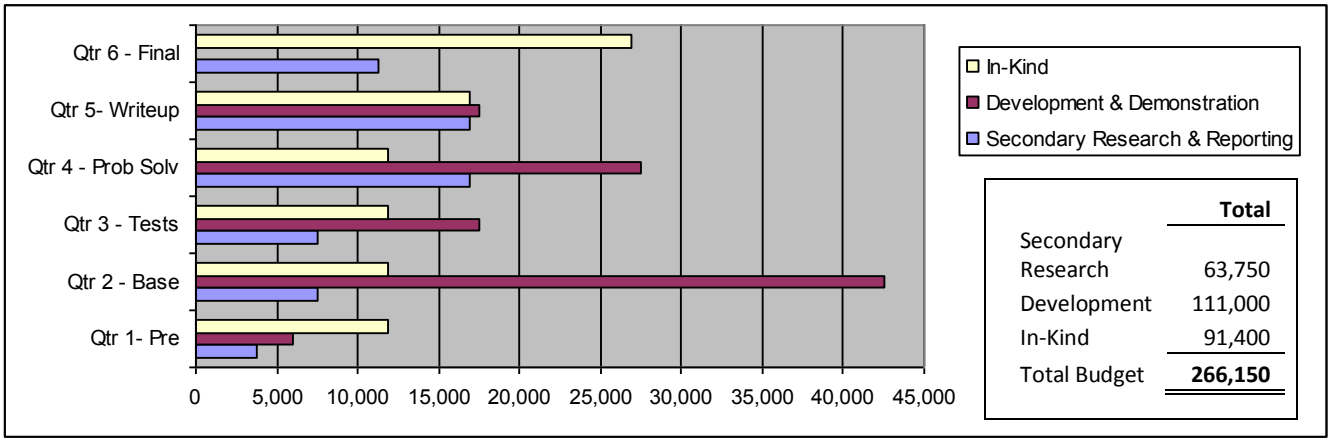
The methodology of this demonstration project will be focused on answering the following questions:

- Can we generate enough electricity to satisfy the needs of an average rural home during the winter months?
- Can we generate enough electricity for that home at a cost effective rate, assuming a 5-year payback rate?

1. Prepare Research Design: Principal Investigator, UAA Associated Professor of Engineering Jeff Hoffman Ph.D., Project Manager, UAA Assistant Professor of Mechanical Engineering Jennifer Brock, and supported by James Foster.
2. Gather and analyze data to determine the average rural home electrical needs and costs associated with those needs. This will be the project control.
3. Test the technology combinations.
4. Compare results to project control.
5. Determine commercial viability of the combinations.



3. Summary of Project Schedule and Summary of Project Budget



	Total
Secondary Research	63,750
Development	111,000
In-Kind	91,400
Total Budget	**266,150**

	Q1 Pre	Q2 Base	Q3 Tests	Q4 Problem Solve	Q5 Write Up	Q6 Submit Final	Total	
Secondary Research & Reporting								
Principle Investigator - Hoffman	1250	1250	1250	1250	1250	3750	$10,000	
Project Manager - Brock	1250	3750	3750	10000	10000	3750	$32,500	
UAA OH Costs	1250	2500	2500	5625	5625	3750	$21,250	
Sub Total	**3750**	**7500**	**7500**	**16875**	**16875**	**11250**	**$63,750**	
Development & Demonstration								
Project Manager - Brock	0	5000	5000	5000	5000	0	$20,000	
UAA OH Costs	0	2500	2500	2500	2500	0	$10,000	
Inventor - Foster	5000	5000	5000	5000	5000	0	$25,000	
Inspection Requirements & Regulations	1000	0	0	0	5000	0	$6,000	
Parts and Supplies (includes 3 stoves)	0	30000	5000	15000	0	0	$50,000	
Sub Total	**6000**	**42500**	**17500**	**27500**	**17500**	**0**	**$111,000**	
AEA Funding Request								**$174,750**
In Kind								
Space Lease - Inventor Foster 1200 sq ft x 1.50/month	5400	5400	5400	5400	5400	5400	$32,400	
Equipment prototype lease wood stove, stack, disp eng	1500	1500	1500	1500	1500	1500	$9,000	
Inventor - Foster	5000	5000	5000	5000	5000	5000	$30,000	
AMEP-Commercialization	0	0	0	0	5000	5000	$10,000	
AMEP-Round 2 Funding support	0	0	0	0	0	10000	$10,000	
TOTAL IN-KIND	**11900**	**11900**	**11900**	**11900**	**16900**	**26900**	**91400**	**$91,400**
TOTAL FROM ALL SOURCES INCLUDING IN-KIND								**$266,150**

4. Project Team Qualifications

- **Principal Investigator: UAA Professor & Chair of Mechanical Engineering Jeff Hoffman Ph.D.**
  Specialties include: Heat transfer, FEA, thermodynamics, renewable energy technologies
  Recently published: *Ice Dam Analyzed*, Journal of Light Construction, March 2010.
  US Patents: Insertion Instrument for Spinal Fixation System, Transient Spray Patternator, and others
- **Project Manager: UAA Assistant Professor of Mechanical Engineering Jennifer Brock**
  Specialties include: Energy, fluid and thermal systems, biosensor design
  Senior Capstone Project Instructor
  Graduate Lecturer, Department of Mechanical Engineering, The Ohio State University, Columbus, OH, September 2007 – March 2009 *Primary Instructor for Heat Transfer*
- **UAA Engineering Students** will work on this for fulfillment of their **Senior Capstone Project** requirement.
- **Inventor: UAA Student pursuing Nondestructive Testing 2-Year Degree, James Foster**
  Proprietor of Jim's Welding, a small welding business. James learned to weld as a young child working with his father, a Master Welder. He invented his first gas generator in 2010.
- **Lean Manufacturing expert, Journeyman Electrician: Brendan Costello**
  Industrial Energy Efficiency Project Manager, Alaska Manufacturing Extension Partnership, Inc.

5. Discussion of Commercialization of Funded Technology

Upon completion of the technical feasibility of the WHHPS, the inventor and AMEP will develop a business plan, three years pro forma financial statements, assist with further design and regulatory testing requirements, conduct a partner search for investors and distributors, and negotiate with viable partners who are motivated to distribute the product to rural Alaska homes.

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.

Jim Foster

James Foster