"Alaskan Concentrating Cogeneration Solar Energy System (ACCSES) Prototype Test Project to Advance Technology Readiness"

Application to:
Alaska Emerging Energy Technology Fund Grant Program
AEA-2014-007

Applicant:
RIC Enterprises Alaska Renewable Energy
Alaska Nonprofit Corporation # 133489
Proof of Eligibility & Certificate of Incorporation are included in Attachment 1
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Project Partners:

Matanuska-Susitna College
8295 College Drive, Palmer, AK 99645

University of Alaska Anchorage
3211 Providence Dr, Anchorage, AK 99508

Partner letters of support are included in Attachment 2

Costs:
Total Project Cost: $249,100
Grant Funds Requested: $186,200
Match Committed: $62,900 (>25%)
Match Commitment is included in Section 6

Previous Application:
"Snow & Ice Supported Wind Energy Powerplant Prototype Test Project to Advance Technology Readiness"
RIC Enterprises Alaska Renewable Energy, with Barrow Arctic Science Consortium, Ilisagvik College,
Inupiat Community of the Arctic Slope, and North Slope Borough
Application to AEA-11-027, not funded

Proprietary Data subject to confidentiality requirements is not included;
RIC Enterprises Intellectual Property material is included

Submission by Express Mail, Mail Date September 3, 2013

Includes one hard copy plus electronic copy in PDF on CD, mailed to:
Alaska Energy Authority
AEA Emerging Energy Technology Grant Application AEA-2014-007
813 West Northern Lights Blvd
Anchorage, AK 99503
Phone:907-771-3000

1. Project Summary

1a. Project Description

The mission of this project is research, development & demonstration (RD&D) on a technology innovation that cost-effectively harvests solar energy for tri-generation of electric power & usable energy for hot water & building heating / cooling.

Foundational Intellectual Property of this technology is described in U.S. patents 7,997,264 & 8,127,760 & application US2011/0277815 all titled to RIC Enterprises, a nonprofit corporation with a focus on renewable energy development. The new solar energy technology builds upon a demonstrated low-concentration solar energy invention called "Surya" (Figure 1) that uses one-axis tracking, a framed inflatable concentrating reflector and cooled photovoltaics to improve cost-effectiveness of solar energy for residential and commercial applications; and upon earlier U.S. DOE-sponsored testing including adverse weather testing of an inflatable heliostat.

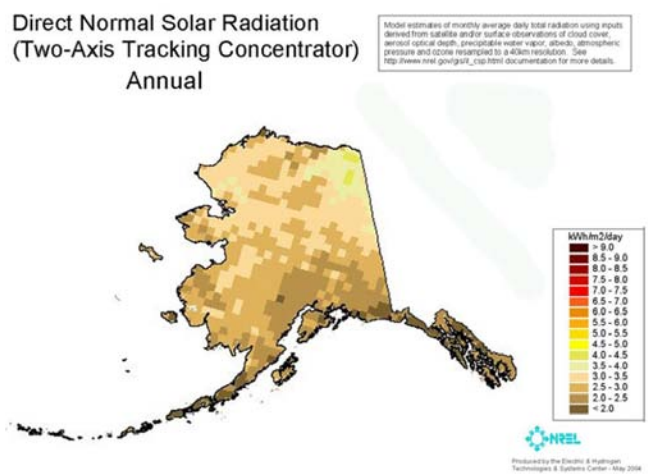
The proposed project is an evolution of the prior prototype work, that will utilize two-axis solar tracking and liquid cooling for cogeneration of 2.3 kWe of electric power and 12 kWt of usable heat for hot water or building heat. With integration of a solar powered heat pump, the system also has potential to serve as a "tri-generation" system to provide building cooling as well as heating.

Figure 2 illustrates that almost all regions of Alaska (excepting particularly cloudy & wet parts of the Aleutians and Alaska Panhandle) receive annual average direct normal solar radiation greater than 2 kW-hr/sq.m/day for a two-axis tracking concentrator. Alaska has strong needs for building heating in addition to domestic hot water in the Fall, Winter and Spring, which makes it a well-suited market for residential, public service and commercial applications of the proposed Alaskan Concentrating Cogeneration Solar Energy System (ACCSES).

The current TRL for the ACCSES Systems is judged to TRL 5. This assessment is based on the fact that the constituent framed inflatable solar low-concentration subsystem is at TRL 5 while structural, mechanical, electrical and control subsystems exist and are well-proven to TRL 8 or 9. Currently, the system requires engineering & test work to integrate the subsystems into a robust tri-generation ACCSES system. The key objectives of the project are (i) to advance the TRL from 5 to 7; (ii) to identify energy, operations and economic potential for ACCSES systems across Alaska; and (iii) to develop technology & business roadmaps to commercialization.

To meet these objectives, an integrated and fully functional full-scale prototype of a tri-generation embodiment of ACCSES will be designed, engineered, manufactured, assembled and tested in a realistic operational environment at the Matanuska-Susitna College in Palmer, Alaska.

Figure 1
"Surya" preliminary prototype for a CPV system with a framed inflatable reflector and 1-axis solar tracking



http://www.akenergyauthority.org/Useful%20pics/solar/Alaska%20Annual%20Solar%202-Axis%20Track%20Big%20Image.jpg

Figure 2
Alaska Annual Direct Normal Solar Radiation for Concentrating Collectors with Two-Axis Trackin

Figure 3 below illustrates the preliminary design of a full-scale prototype ACCSES concentrated photovoltaic (CPV) module and system designed to produce 2.3 kWe of electric power and 12 kWt of useful thermal (heat) output. A rotating "goal post" support frame similar to football goal posts, is used to support the device while providing azimuthal tracking of the Sun. Elevation tracking is provided by rotating an elevation pivot beam that is rigidly connected to both a solar receiver fitted with high-efficiency monocrystalline silicon solar cells, and to the framed inflatable mirrors that reflect and concentrate incoming sunlight onto the solar receiver. Liquid cooling is provided on the back side of the solar receiver with the use of an effective nontoxic and cold-resistant heat transfer liquid. The closed-loop heat transfer liquid then transfers useful heat to a hot water tank / building heating module through a heat exchanger, and will also be tested with connection to a mini-split heat pump for tri-generation providing building cooling or additional heating depending on seasonal requirements. Thus in the proposed full-scale prototype demonstration and testing plan, the Fall/Winter/Spring seasons demonstrations will include solar cogeneration concurrently providing electric power and hot water and building heat, while the Summer season demonstration will include solar tri-generation concurrently providing electric power and hot water and building cooling.

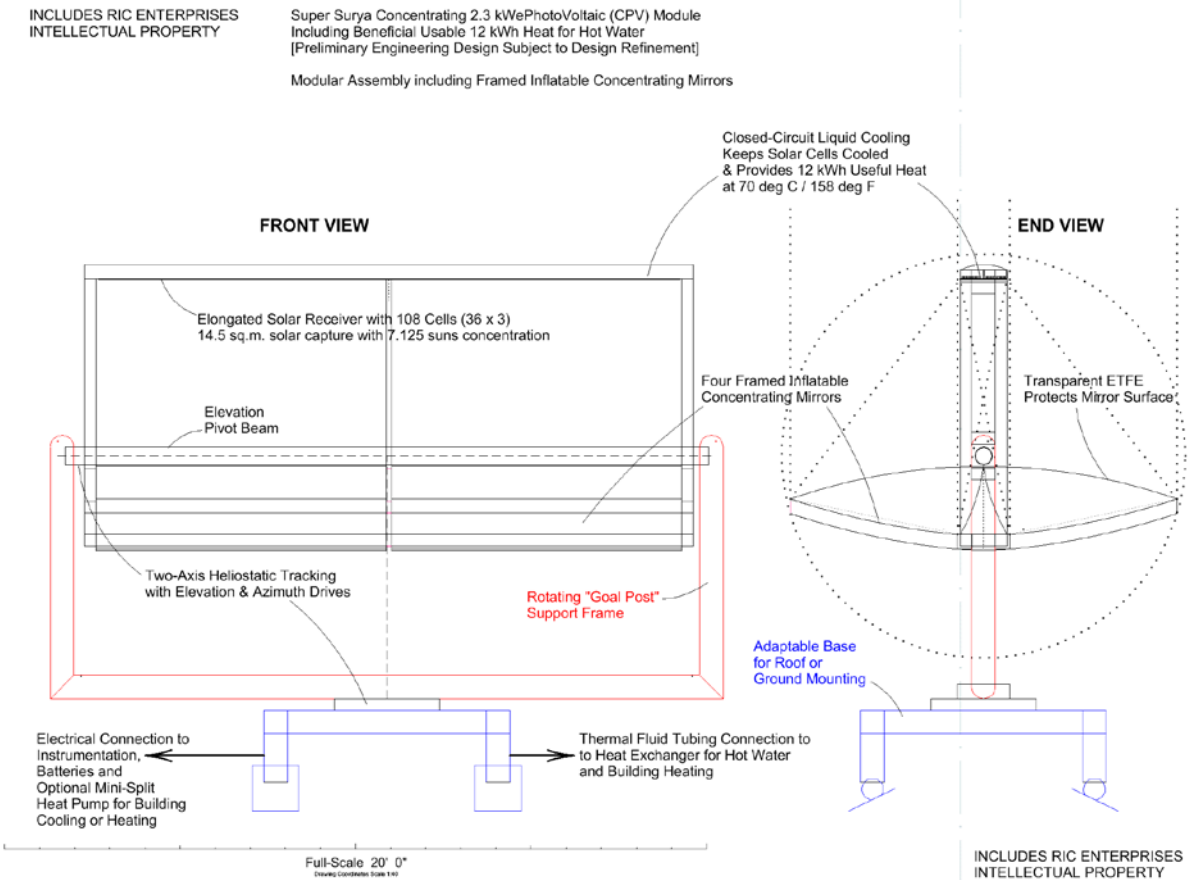


Figure 3 Prototype ACCSES CPV Module and System Design

1b. Project Innovation

The innovation of ACCSES is focused more on inventive leverage and integration of proven technologies than on exotic technologies that are extremely expensive or at very low TRL. This is intended to enable a system that is rugged and reliable in environments such as Alaska. The design offers significant advantages over traditional fixed-mount solar panels as it uses two-axis solar tracking to orient the high-efficiency CPV cells at the optimal angle to maximize solar energy harvest throughout the year despite highly variable Sun paths in Alaska. The heat produced during the solar energy harvest is removed from the system by a heat transfer liquid for cogeneration of 12 kWt of usable heat. The framed inflatable mirrors with ETFE covering improve the cost-effectiveness of the system as each CPV cell harvests over 7 suns of concentrated insolation. The ETFE covering is also self-cleaning in rain and the module is inverted-stow-capable for severe adverse weather conditions such as a hailstorm. With integration of a solar powered heat pump, the system is intended to serve as a "tri-generation" system to provide building cooling or additional heating, with very high Coefficient of Performance (COP) and Seasonal Energy Efficiency Ratio (SEER) for selected Alaskan market applications. .

1c. Project Site and Demonstration Environment

Subassembly fabrication will occur at contractor fabrication sites and RIC Enterprises managed sites in Washington State, and assembly and Phase 1 checkout testing will also take place at the Washington State test site. The ACCSES system will be disassembled & shipped and final reassembly will take place in situ at the planned test site at the Matanuska-Susitna College in Palmer, Alaska. Site control and any permits will be provided by the Matanuska-Susitna College, a partner organization for this project. The test site will have good road and power access for researchers from RIC Enterprises, the Matanuska-Susitna College, and the University of Alaska Anchorage. The test site is located in the Anchorage-Fairbanks corridor and is representative of many potential residential, public service and small commercial markets across Alaska.

1d. Priority

We respectfully submit that this project aligns well with the prioritization criteria for the Emerging Energy Technology Funds, for all of the following reasons: 1. The applicant and project partners and supporting organizations are all Alaska entities. 2. Partnership with the University of Alaska or post-secondary institution is included with committed partnership from both the Matanuska-Susitna College and the University of Alaska Anchorage. 3. A commitment is made for in-kind and cash matching at a >25% level. 4. Strong potential exists for widespread deployment over a substantial majority of Alaskan regions, which will be quantified by a graduate student researcher from the University of Alaska Anchorage as part of this project. 5. ACCSES represents a tri-generation system that generates useable electricity, hot water and building heating or cooling.

2. Technology Validation and Data Collection

2a. Objectives

A primary objective of this RD&D project is to advance the TRL for ACCSES from TRL 5 to TRL 7 as described in Section 1a above. Table 1 below shows the key performance metrics to be used to evaluate performance of the ACCSES prototype.

Table 1: Key Performance Metrics of a fully functional, full-scale prototype tri-generation ACCSES

Insolation Capture Area (sq.m)	14.5
Solar Concentration by Framed Inflatable Mirrors (Suns)	7.125
Rated Electric Power (kWe)	2.3
Rated Useful Thermal (Heat) Output @ 70 ± 10 ºC (kWt)	12
Representative Heat Pump Sizing For Prototype (BTU/hr)	12000
CPV Module Installed Diameter Envelope (ft)	20
Inverted Storm Stow Design Conditions For Alaska	Heavy snowfall; 1” hail; Beaufort 9 strong gale, 54 mph wind

2b. Data Collection

Technical data will be collected using the following instrumentation: temperature and wind and sunlight sensors, CPV cell temperature sensors (e.g., thermocouples), electric power measurement sensors, battery bank energy sensors, thermal fluid temperature and flow sensors, water tank temperature sensors, heated and cooled building temperature sensors, heat pump sensors, other sensors, datalogger system, still and video cameras, and a computer for control and recording measurements.

3. Project Schedule and Project Budget

A high-level overview of the project budget is detailed below. The committed project match includes cash and in-kind contributions from RIC Enterprises and Matanuska-Susitna College, reduced labor rates, partially unreimbursed travel expenses, partially unreimbursed general and administrative (G&A) expenses, partially unreimbursed overhead expenses, and partially unreimbursed teaching and training of Matanuska-Susitna College and University of Alaska Anchorage students supporting the project.

Project Budget	TOTAL	Pre-Deployment	Deployment&Research	Post-Deployment
Total Project Cost:	$249,100.	$118,800	$118,550	$11,750
Grant Funds Requested:	$186,200.	$92,600	$86,600	$7,000
Match Committed:	$62,900.	$26,200	$31,950	$4,750

Figure 4 and Table 2 below outline the project schedule and key project milestones, while Attachment 3 provides supporting detail for the Pre-Deployment, Deployment & Research, and Post-Deployment phases of the proposal. .

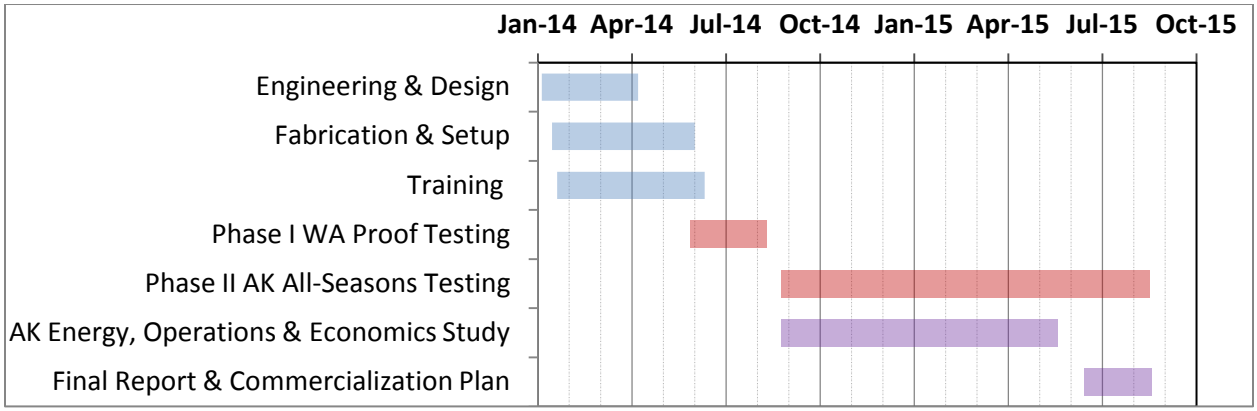


Figure 4 ACCSES Project Schedule

Table 2: Summary of Project Schedule and Key Project Milestones

#	Milestone Description	Date	#	Milestone Description	Date
1	Project Charter Document	1/25/2014	6	Phase I Test Complete in WA	8/16/2014
2	50% Design Review	2/28/2014	7	Energy, Ops & Economics Study	5/30/2015
3	Test Site Permits	3/10/2014	8	Phase II Test Complete in AK	7/25/2015
4	Parts & Material Specification	3/25/2014	9	Commercialization Plan	8/15/2015
5	Final Design Review	4/10/2014	10	Final Performance Reports	8/31/2015

4. Project Team Qualifications

The RIC Enterprises and collaboration team collectively has over two hundred years of professional experience and ten postgraduate degrees, and a strong track record of innovation with over 50 issued patents and many prototype projects. Roles of selected key proposal team members are tabulated below, and summary Curriculum Vitae are included in Attachment 4.

Team Member Name	Role in Project	Exemplary Supporting Qualifications
Mithra Sankrithi	Principal Investigator	Ph.D. Princeton; PI for DOE-sponsored research; 47 patents
Wm Roeseler	Chief Engineer Structures	Masters MIT; 43 years at Boeing & United Technologies
Gary Reysa	Chief Engineer Solar Equipment	35 years Boeing; Founder & Principal of builditsolar.com
Tom Ravens	UAA Professor & Graduate Advisor	Ph.D. MIT; Professor University of Alaska Anchorage
Mark Masteller	Matanuska-Susitna Site Focal	Director of Renewable Energy Program, Mat-Su College

5. Discussion of Commercialization of Funded Technology

This project will advance TRL for the tri-generation ACCSES from TRL 5 to TRL 7. Roadmapping methods will be used to synthesize technology & business roadmaps needed to get to TRL9. The roadmaps will include a sequence of critical elements needed to enable viable technical and business development and low-rate pre-production implementation by RIC Enterprises in conjunction with supporting suppliers and partners. A preliminary product development plan will also be developed and documented for deployment and in-service monitoring of ACCSES systems in many locations in Alaska by 2016. This plan will include engineering, procurement, manufacturing, shipping, assembly, operational, financial, business / contractual, legal / regulatory, political, community service and environmental benefit considerations.

6. Signed Applicant Certification & Match Commitment

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