ALASKA ENERGY AUTHORITY RFA 12-047: EMERGING ENERGY TECHNOLOGY FUND

PROJECT TITLE:

HIGH VOLTAGE DIRECT CURRENT TRANSMISSION SYSTEM FOR RURAL ALASKA APPLICATIONS

PHASE III – CONVERTER TECHNOLOGY DEMONSTRATION PROJECT

SUBMITTED MARCH 9, 2012

APPLICANT ORGANIZATION & CONTACT:

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APPLICANT PARTNERS:

PRINCETON POWER SYSTEMS

NRECA CRN™ COOPERATIVE RESEARCH NETWORK

UAF UNIVERSITY OF ALASKA FAIRBANKS

MANITOBA-HVDC RESEARCH CENTRE

TOTAL PROJECT COST: $1,600,000

EETF Grant:	$1,500,000
Applicant/Partner Match:	$ 100,000

PREVIOUS PROJECT PHASES:

HVDC Transmission System For Rural Alaska Applications
Phase I – Preliminary Design and Feasibility Analysis
Funded by: Denali Commission, Project #356-07
Completed: August 2009

HVDC Transmission System For Rural Alaska Applications
Phase II: Prototyping and Testing
Funded by: Denali Commission, Award #01201-00
Completion Date: March 2012

PREVIOUS EETF APPLICATION TITLE: SAME AS CURRENT APPLICATION

PROJECT ABSTRACT

1.0 PROJECT SUMMARY

1.1 PROJECT DESCRIPTION

High voltage direct current (HVDC) power transmission is a proven commercial technology with dozens of installations in service world-wide. HVDC is recognized as superior to alternating current (AC) power transmission in certain applications, for the following reasons:

- Ability to use long distance submarine or buried overland cables,
- Superior long distance electrical efficiency and capital cost,
- Superior reliability and flexibility – HVDC provides an asynchronous intertie connection, and
- Fewer wires are needed and simpler, less costly structures are possible.

Interties between Alaska's rural villages would benefit from many of these attributes of HVDC transmission. Unfortunately, existing HVDC systems are designed to move 50 to 1,000s of megawatts (MW), which is far more than Alaska's villages need. Several proposed Alaska interties have explored using HVDC, but commercially-available HVDC converters are too large and costly to be practical.

Polarconsult Alaska, Inc. (Polarconsult) and Princeton Power Systems (PPS) have been working with Alaska's rural utilities and industry stakeholders since 2005 to develop a small-scale HVDC transmission system that is 'right-sized' for Alaska village interties. With funding from the Denali Commission, this HVDC concept has been advanced from idea to a one-MW prototype converter consisting of two 500 kW modules. Each 500 kW module is capable of bi-directional power conversion between three-phase 480VAC and 50 kV DC.

Polarconsult and PPS propose to continue development and demonstrate real-world operation of this HVDC converter. The proposed project goals include upgrading the existing prototype converters, completing functional, confidence, and compliance testing of the converters, conducting third-party testing of converter functions and performance, and possibly deploying the converters on an operational HVDC intertie in Alaska. The goal of this phase of the project is to produce a commercially-proven HVDC converter suitable for use in Alaska.

1.2 PROJECT ELIGIBILITY

The proposed project is eligible under AS 42.45.375(2)(c)(1)-(3) and AEA RFA #12-047 as follows:

(1). This HVDC technology is an emerging energy technology,

(2). This converter improves on existing HVDC technology, which is not commercially available at the power levels needed for many Alaska applications, and

(3). This project will be the first deployment of HVDC transmission technology in Alaska.

1.3 PROJECT INNOVATION

Small-scale HVDC transmission can dramatically reduce the capital cost of interties. The capital cost of building a remote one MW AC overhead intertie in rural Alaska is $200,000 to $600,000 per mile. Comparable HVDC interties can be built at as little as half this cost. Including the cost of the HVDC converters, significant savings are realized on interties longer than 8 to 10 miles. Savings of $2+ million are achievable on a single 25-mile intertie by using HVDC instead of AC.

These savings are possible for the following reasons:

1. Overhead HVDC interties require only one or two wires, as compared to three or four wires for AC. This achieves immediate savings through a reduction in wire and their associated installation cost.
2. Reducing the number of wires allows for longer spans, as it is easier to keep the wires from touching. It also reduces the wind, wire, and ice loads on poles. This enables the use of fewer and/or less costly poles, resulting in lower material costs and reduced construction effort.
3. Optimizing intertie designs for the logistical and geotechnical challenges common in Alaska achieves further savings. For example, optimized designs can enable utilization of Hughes 500 or Bell UH-1 type helicopters to install structures within 'roadless rule' areas of the Tongass National Forest, or eliminating heavy steel pile foundations to support poles in the Yukon-Kuskokwim region.

This technology also opens up new possibilities for submarine cable interties. Savings of $15 to 20 million are possible for a single 25-mile submarine cable intertie in southeast Alaska. Also, HVDC submarine cables can be used in applications where AC submarine cables are not technically feasible.

1.4 PRIORITY

This project meets all of the priority criteria set forth in AS 42.45.375(d)(1) through (4) as follows:

(1). Polarconsult is an Alaska business owned by and employing Alaska residents.

(2). Polarconsult has partnered with the University of Alaska Fairbanks (UAF), and the Alaska Center for Energy and Power (ACEP) to complete the proposed project.

(3). The application includes applicant matching funds.

(4). The successful commercialization of this technology will have an immediate potential for widespread Alaska deployment. Phase II of this project investigated a dozen interties around Alaska that could save costs by using HVDC. There are likely dozens more.

2.0 TECHNOLOGY VALIDATION AND RESEARCH METHODOLOGY

2.1 OBJECTIVES

Previous efforts on this project have produced two 500 kW prototype converters. Tests have demonstrated the basic converter functionality, validating the key technology elements of the converter design. These efforts have raised the converter technology from Technology Readiness Level (TRL) 1 up to TRL 6. Previous efforts have also evaluated the economics of low-power HVDC interties, and found that they can have substantially lower life cycle costs than AC interties.

This phase of the project will focus on continuing development of the HVDC converters with a goal of advancing the system from existing TRL 6 up to TRL 9. This project intends to culminate in a four-season demonstration deployment of the beta-level converters on an operational Alaska HVDC intertie.

The proposed R&D program includes two major 'go/no-go' review checkpoints to evaluate progress. Funds may be reallocated at these checkpoints based on project progress. This management structure provides flexibility to focus funds on optimal advancement of the HVDC technology and system. The program includes the following task objectives:

A1. Upgrade the existing alpha-level prototype converters to beta level units. PPS will be primarily responsible for design, fabrication, procurement, and assembly efforts to upgrade the converters.

A2. Define compliance protocols for the converters that will be acceptable to utilities and prospective commercial users of the technology. Polarconsult has partnered with UAF, the Manitoba HVDC Research Centre (MHRC), and the National Rural Electric Cooperative

Association's Cooperative Research Network (NRECA-CRN) to define the appropriate testing protocols and certifications for the converter hardware and system interconnection standards.

A3. Perform functional, confidence, and compliance testing of the beta-level converters. PPS will be primarily responsible for testing the beta-level converters. MHRC, NRECA-CRN and UAF will assist PCA in overseeing testing efforts.

A4. Design and build converter enclosures. Polarconsult will design and procure converter enclosures suitable for use on Tasks B and C.

At the conclusion of Tasks A1 through A4, the project team will review Task A converter results to validate that continued work on the project is warranted.

B1. Independent Validation of Converter Functionality. Upon successful completion of Tasks A1 through A4, the converters will be integrated with their enclosures and moved from PPS facilities in New Jersey to the ACEP facility in Fairbanks for independent testing and verification. UAF's Dr. Richard Wies will have primary responsibility for managing and overseeing the converter testing.

B2. Design of HVDC Switchyard and Grid Integration System. Polarconsult and its partners will identify a suitable site for demonstration of the converters on an Alaska utility system. Once a site is selected, Polarconsult will coordinate design of the HVDC switchyard and AC interconnections.

B3. Modeling of HVDC Transmission Intertie. Polarconsult, UAF, PPS, and MHRC will collaborate on modeling the power converters in the Task C demonstration setting. The modeling will identify any technical issues that need to be addressed prior to field deployment of the converters.

At the conclusion of Tasks B1 through B3, the project team will review Task B findings to validate that the converters are ready for field deployment.

C1. Demonstration Line Build. Polarconsult will coordinate preparation of the line for HVDC service. Polarconsult is actively working with Golden Valley Electric Association, Inc. (GVEA) to identify a suitable site on the GVEA system. Other sites in Alaska may also be considered.

C2. HVDC Demonstration. The demonstration line will be operated as a HVDC line from the fall of 2013 through the summer of 2014 to obtain a four-season performance record for the converters in an interior Alaska climate.

C3. Conversion of Line to AC. At the conclusion of the demonstration project, the HVDC converters and associated equipment will be removed and the intertie will be converted to AC operation.

2.2 METHODOLOGY

The project budget and progress will be reported to the Authority on a quarterly basis. Technical and economic data collection efforts will focus on the following information:

1. Performance and efficiency data for the converters under laboratory and field conditions.
2. Economic data collected in Phase III will be used to update the existing system economic analyses.
3. Periodically over the course of the project, CRN will provide targeted education, outreach, and communications to national and international markets for this technology.

Data will be reported by Polarconsult through task-specific reports. At the conclusion of the project, these reports will be compiled into a final report with a brief narrative that explains the overall Phase III project effort, accomplishments, and implications for Alaska interties.

3.0 PROJECT SCHEDULE AND BUDGET

3.1 SCHEDULE

Tasks A1 through A4:	August 2012 – April 2013
Task B1 through B3:	May 2013 – August 2013
Task C1 through C3:	September 2013 – August 2014

3.2 BUDGET

The proposed budget for this project is $1,600,000. This includes $100,000 in match: $50,000 as in-kind services from Polarconsult, and $50,000 as in-kind services from PPS.

4.0 PROJECT TEAM QUALIFICATIONS

The project team includes Polarconsult, PPS, UAF/Dr. Wies, MHRC, and NRECA-CRN. Core members of this team have worked successfully over the past five years advancing this HVDC system.

Polarconsult is a professional engineering consulting firm headquartered in Anchorage since 1978. Polarconsult specializes in innovative, affordable and robust engineering solutions tailored for Alaska conditions. Polarconsult has successfully served over 200 municipal, public, and private-sector clients throughout Alaska. Polarconsult's project manager for this project will be Joel Groves, PE. Mr. Groves has managed Phases I and II of the HVDC system development efforts.

PPS designs and manufactures advanced power systems for military, public, and private-sector clients. PPS utilizes advanced and proprietary technologies to develop power systems that meet stringent power quality, efficiency, environmental, cost, reliability and performance specifications. PPS efforts on this project will be led by Frank Hoffman, Ph.D.

Dr. Richard Wies, Ph. D, P. E., an Associate Professor of Electrical and Computer Engineering at UAF and a registered Electrical Engineer in the State of Alaska, has over 12 years of research experience focused on stand-alone hybrid electric micro-grid systems. His current research interests include developing smart grid controls for the stable and efficient operation of stand-alone hybrid wind-diesel-battery-thermal storage micro-grid systems in Alaska villages. He also has an interest in developing HVDC transmission systems to connect villages and export Alaska's stranded energy resources.

MHRC is an internationally recognized leader in research and development of power systems, including HVDC, AC, power electronics, and related technologies. MHRC efforts on this project will be led by Randy Wachal, MHRC's Engineering Systems Manager.

CRN is the research arm of the NRECA. For over a decade, CRN has provided pertinent, timely research to assist electric cooperative utilities in addressing a wide array of technology and operational challenges. CRN efforts include investigative reporting, in-depth analysis, the production of guides and handbooks, product evaluations and technology demonstrations. CRN personnel on this project will include Tom Lovas in Alaska, as well as Doug Danley and Bob Saint, PE.

5.0 COMMERCIALIZATION OF FUNDED TECHNOLOGY

This phase of the project is planned as the final pre-commercial phase for the converter development. At the end of the field demonstration in 2014, the converter will be fully tested in an Alaska environment and considered ready for commercial service. CRN's communication and outreach efforts will help raise awareness of this technology and its benefits to the broader national and international markets, bolstering commercialization prospects due to the broader market exposure. This could dramatically improve system economics through reduced equipment costs.