Alaska Energy Authority
Emerging Energy Technology Fund Application
September 5, 2013

Proposal Title:	Energy Efficient Water Recycle Project
Applicant Contact Information:	Enhanced Water Recovery 110 West 15th Avenue Anchorage, AK 99501 (907)770-6367 EWR@Yahoo.com
Partners:	Intelligent Energy Systems, LLC Alaska Resource Methods Carol E. Lewis, Ph.D., Dean, Director and Professor Emeritus, UAF School of Natural Resources and Agricultural Sciences and Agricultural and Forestry Experiment Station
Total Project Cost:	$345,000 Grant Funds Requested $275,000 Matching Funds $70,000
Previous Grants:	None
Previous Abstracts:	None

Energy Efficient Water Recycle Project - Enhanced Water Recovery

Project Summary

a. Project Description

Personal health in villages is threatened by energy costs and limited access to clean water and wastewater management. Fuel-based energy systems are significant factors in determining local accessibility to clean water and sanitation. Hybrid wind / diesel power plants offer some relief but few village services systems are available to take advantage of the intermittent and unpredictable nature of wind power. We propose to put into service a highly energy efficient wastewater treatment system that improves village sanitation as well as increases clean water availability by recycling 95% of that water for reuse. The system can operate intermittently, tracking wind energy production, and provides an effective method for storing that energy until needed.

The wastewater treatment system is based on the method of Forward Osmosis (FO). FO treats wastewater using a hydrophobic membrane similar to reverse osmosis (RO), but unlike RO, which utilizes a hydraulic pressure difference, FO utilizes an osmotic pressure difference as the driving force for water diffusion across the membrane. Advantages of the FO process in wastewater treatment include low fouling potential, low energy consumption, simplicity, and reliability. Resistance to fouling and the ability to treat high solid feeds occur because the feed stream flows are maintained at a very low hydraulic pressure and a high cross flow velocity. A salt solution (osmotic agent, AO) is used on one side of the FO membrane to provide the osmotic potential to drive the movement of water from the wastewater into the salt solution. To collect the purified water, the salt solution is presented to an RO membrane and the pure water extracted. The selection of a salt and a complimentary RO membrane allow the RO system to operate under optimal conditions. This Forward Osmosis Water Recycle System (RO-WRC) combines FO and RO in near optimal operating conditions for each technology, providing a high water recovery rate (90%), effective wastewater treatment, low energy use, and reliability (figure 1).

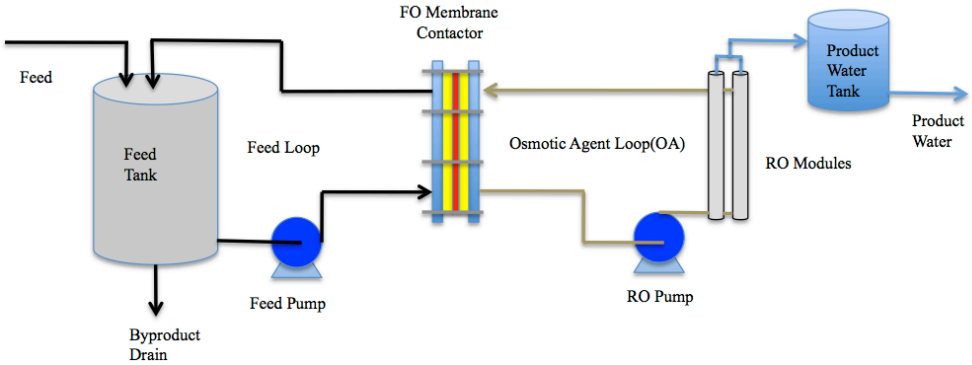

Figure 1. The Forward Osmosis Water Recycle System (FO-WRS) flow diagram.

The FO-WRS operates in a continuous flow configuration with purified water being removed from graywater via FO and water recovered from the salt solution loop via RO. This both produces purified product water appropriate for reuse and reconstitutes the salt solution. The FO supply operates in a semi-batch mode where the feed tank is filled with graywater and re-circulated through the FO module until 95% of the water is removed. The water is continuously removed while the resulting concentrated byproduct in the graywater feed tank is dumped thus providing adequate flow for flushing of the system to the wastewater lagoon. After dumping, the graywater tank is refilled. The osmotic drive for FO is provided by a 10% sodium chloride (NaCl) salt solution. The salt solution system is operated in a closed-loop configuration. The RO product water is pumped to a holding tank and used as flush water for the toilets in the building.

The FO-WRS to be installed in this project is presently at Technology Readiness Level 8 or 9. The system is a larger version of a technology developed by NASA for the treatment of spacecraft

wastewater. The system is currently in operation in the Sustainability Base, a new Green Building at NASA's Ames Research Center constructed to LEED Platinum construction standards. The system is designed to meet the California Department of Public Health Regulation Related to Recycled Water. All operation and maintenance schedules, procedures and resupply needs have been developed to support the Sustainability Base installation and are being verified there. The system produces 42 gallons of water per hour. Energy use is 75 Wh per gallon (for comparison approximately 912 Wh is necessary to melt snow for 1 gallon of water).

b. Project Innovation

A major innovation resulting from this project will be availability of a low-cost, highly energy efficient, wastewater treatment system capable of increasing the grid penetration of renewable power and energy storage. Additionally, a new and appropriate wastewater treatment approach not previously considered for Alaska applications will be advanced to a solid TRL level 9 and near commercial readiness.

c. Project Site and Environment

We propose this energy efficiency / energy storage wastewater treatment project for the village of Kipnuk or Kongiganak. Both villages have a Washeteria supplied by a central water system. The Washeteria provides facilities for clothes washing, showering and hygiene, and has the only flush toilets in either of the communities . It is our intention to install the FO-WRS in the Washeteria, connect it electrically to the power plant, and supply communications to the power plant. The purified water recovered from the washeteria graywater (hygiene and wash water) treatment will be used to fill a storage tank and provide flush water for toilets. Excess water will also be appropriate to supplement fresh water used by washing machines. The power plant and water systems are operated under the same management. In both Kipnuk and Kongiganak, IES, a partner in this project, is developing hybrid power generation.

Currently, Kongiganak plans to construct a new Community Center for the village at a location adjacent to the Washeteria. This will replace the current Community Center which has only honey-bucket facilities. The FO-RWS described here may be able to accommodate the new Community Center. An additional FO-RWS could be added as determined appropriate at the time of construction of the new center.

d. Priority

This application meets all four of the stated priority considerations listed in AS 42.45.375(d) and the Alaska Energy Authority's Request for Application (RFA sec. 1.6).

1. **Alaska residents, associations, organizations, or institutions** – This project will serve an Alaska community by increasing energy efficiency, providing renewable energy storage and improve sanitation and availability of clean water. The company proposing the project and partners are all Alaskan companies.
2. **Projects that demonstrate partnership with the University of Alaska or another Alaska post-secondary institution** - Carol E. Lewis, Ph.D. and MBA, Dean, Director and Professor emeritus of the University of Alaska Fairbanks will be involved in economic analysis of both energy and water related impacts within the community. As co-owner of Alaska Resource Methods, she has worked with rural communities and individuals in Alaska since the early 1980s.
3. **Projects supported by matching funds or in-kind partnerships** – There is an approximate 25% in-kind matching of funds committed by a combination of the proposing company and the two partner companies.
4. **Projects with potential for widespread deployment in the state** – The system to be demonstrated in this project will have widespread applicability throughout Alaska. The system is well suited to fit into a renewable energy power grid but the overall energy

efficiency, improved sanitation and clean water supply will make it practical for most communities.

1. Technology Validation and Data Collection

a. Objectives:

1 - Quantify increased power grid penetration in hybrid wind / diesel power environment, in particular the response time of the system to power and determination of any critical power on operational periods.

2 – Quantify community impact, energy storage and anytime availability of system operation.

3 – Validate long-term performance of water treatment technology (water quality, water recycle ratio, waste rejection, power use) and refine operations and maintenance procedures to facilitate Alaska community use.

4 - Compare performance with a prior installed unit operating in a California office building.

b. Data Collection:

The system will be integrated with the power plant control system. The FO-WRS includes a dedicated control package but will operate only when acceptable conditions for operation are determined by the power plant controller (or operator). Performance data related to power objectives will primarily be collected via the power plant system. Water related performance data will be collected via the FO-WRS control system. We anticipate using the communications system from the power plant to provide remote access to the FO-WRS.

3. Project Schedule and Budget

a. Schedule

Phase 1 – Select village location and prepare site integration plan; 4 months.
Phase 2 – FO-WRS assembly and pre-deployment testing; 6 months.
Phase 3 – System installation and start-up, training, power plant integration; 2 months.
Phase 4 – Operations: Collect one year of data; quarterly data review with team, power / water system community manager.

b. Budget – The projected budget by expenditure allocation:

RO-WRS Hardware / Equipment	$85,000
Site Integration	$30,000
Analysis & Testing	$10,000
Contractual	$150,000
Total	$275,000

4. Project Team Qualification

The principals in Enhanced Water Recovery have experience in supplying Alaska village services and providing water and energy systems for extreme environments. Dennis Meiners has over 10 years involvement in village power systems and high penetration wind turbine projects. Michael Flynn and David Bubenheim have developed water and power systems for NASA for over 20 years – including the FO-WRS and the cold weather wind turbine commercialized by Northern Power System (Northwind 100).

The technical engineering team composed of EWR and IES personnel represent expertise in water and power system design, construction and operations in remote and extreme environments. The team includes former UAF personnel who participated in development of the FO system - David Wilson and Greg Schlick.

Carol E. Lewis has a thirty year history of quantifying and reporting the impacts of technology on the economy and lifestyle of Alaskan communities.

5. Discussion of Commercialization of Funded Technology

The FO-WRS addresses issues important to utilization and management of power in Alaska as well as issues of sanitation and water supply. Energy, sanitation and clean water are critical infrastructure elements for an economically and socially thriving community. The FO-WRS has potential for even greater application to village sanitation and water supply than what is included in this proposal. We are already developing the front-end component to accept raw sewage as the input and utilization of the recovered water to provide for hygiene and potable quality water. Over the next 5 years we anticipate the FO-WRS to have widespread adoption across Alaska with potential for international export.

6. Signed Applicant Certification

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

David Bubenheim
Enhanced Water Recovery