Environment and Natural Resources Trust Fund
2009 Phase 2 Request for Proposals (RFP)

LCCMR ID: 106-D2

Project Title: Demonstration of a Geo & Solar-thermal Powered Residential CHC Microgrid

Total Project Budget: $ $564,170

Proposed Project Time Period for the Funding Requested: July 1, 2009 to December 31, 2011 - 2.5 yr

Other Non-State Funds: $ $0.00

Priority: D2. Residential Energy Conservation

First Name: Louise **Last Name:** Goldberg

Sponsoring Organization: U of M

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Minneapolis MN 55414

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Region:	County Name:	City / Township:
SE	Olmsted	Rochester

Summary: The demonstration of the significant residential energy conservation that can be realized by implementing an economical renewable geo- and solar-thermal energy based combined heating and cooling microgrid utility energy system.

Main Proposal: 0908-2-016-proposal-2-2009-LCCMR-Propsal-Phase-2.doc

Project Budget: 0908-2-016-budget-2-2009-LCCMR-Proposal- Ph2-Budget.xls

Qualifications: 0908-2-016-qualifications-2-Qualifications.doc

Map:

Letter of Resolution: 0908-2-016-resolution-2-2009-LCCMR-Proposal-Ph2-RPUletter.pdf

MAIN PROPOSAL

PROJECT TITLE:

Demonstration of a Geo- and Solar-thermal Powered Residential Combined Heating and Cooling Microgrid

I. PROJECT STATEMENT

The residential energy conservation realized by the efficiencies of geothermal space heating and cooling systems has been well demonstrated, particularly with respect to reducing peak summer electrical demand. The barrier to their large-scale residential deployment is the high first cost (chiefly due to the cost of vertical and/or horizontal ground heat exchangers) and resulting long simple payback (reported as 19.1 years in Minneapolis in a 2008 MN Dept. of Commerce report). Recently completed research at the University of Minnesota, Rochester on hybrid waste heat/geothermal energy space conditioning systems (HESS II) has experimentally demonstrated significantly enhanced, consistent heat pump performance (COP > 5.5 in heating mode, a >53% improvement). This project is aimed at demonstrating the patented HESS II technology in a combined residential heating and cooling microgrid (or district thermal system) including 3-4 homes using solar thermal energy for space heating to very significantly reduce the first cost and payback of solar/geothermal systems by a factor of at least 2, so essentially eliminating the cost barrier to their large-scale deployment. This reduction is achieved mainly by realizing the very large cost reductions in per home ground heat exchanger costs achievable by implementing the HESS technology in a microgrid configuration. The project also will demonstrate the economics of deploying such systems using a "Conservation Utility" financing model in which the plant is owned by the Utility and financed through the rate structure based on "negative energy generation" or energy savings relative to conventional systems.

II. DESCRIPTION OF PROJECT RESULTS

Result 1: Build a 3-4 home CHP demonstration microgrid Budget: $473,109

3-4 neighboring homes in Rochester, MN each will be fitted with a high performance HESS version III heat pump and rooftop evacuated tube solar thermal collectors. This plant will be connected to a central microgrid station via a 3-pipe closed loop fluid system in two tiers in a ~ 6ft deep trench. The bottom tier will contain the potable water line while the upper tier will have the supply and return heating/cooling fluid lines. The potable water line also serves as the horizontal geothermal heat exchanger so eliminating the cost for this component and would be fully code compliant as a once through system with geothermal heat extraction isolated by a double-walled heat exchanger. A very limited number of vertical geothermal wells also will be provided as peak cooling demand backup (no more than 1 per house) so cutting this cost by a factor of at least 4 on a unit dwelling basis. The 3 lines and geothermal wells will be connected to a multistage, stratified thermal storage system in the central station based on the high performance design demonstrated in the HESS II project. The central station will be a heavily insulated ~500ft^2 above-grade structure within a half-mile of the homes. The entire system will be centrally controlled by a globally optimizing digital control system employing neuro-fuzzy algorithms with full remote control, again based on demonstrated HESS II technology.

	Deliverable	Completion Date
1	Occupied, fully functional 3-4 house combined heat and power microgrid	13 months after start date
2	Fully automated and remote-controlled data acquisition and control system producing continuous real time data that will be publicly available via the Internet.	16 months after start date

Result 2: Development of performance and cost data Budget: $75,003

The microgrid system will operated for a period of a full calendar year with energy performance and operating cost data compiled on a continuous basis. At the end of the operating period, these data will be analyzed and reported.

	Deliverable	Completion Date
1	Annual energy performance results showing energy savings relative to conventional heating and cooling plant	28 months after start date
2	Annual operating costs and plant investment return	28 months after start date
3	Comprehensive final report.	30 months after start date

Result 3: Conversion of microgrid to permanent infrastructure Budget: $16,058
The research instrumentation will be removed and the microgrid handed over to the Utility as functional permanent infrastructure. This will included all the necessary cost data to enable the Utility to charge the homeowners for the supplied heating and cooling energy at a rate that would allow the plant investment cost to be recovered based on the avoided cost of conventional energy sources (electricity or natural gas)

	Deliverable	Completion Date
1	Revenue generating heating and cooling microgrid	30 months after start date
2	Permanent demonstration model for propagating the HESS microgrid technology	30 months after start date

III. PROJECT STRATEGY AND TIMELINE

A. Project Partners

Co Principal Investigators Hal H.Ottesen, Ph.D and James P. Licari, Ph.D, University of Minnesota, Rochester.

Rochester Public Utilities (RPU). RPU will be a full partner in the project with responsibility for finding and liasing with a residential developer to build the homes to be included in the microgrid. RPU also will assist in building the necessary microgrid infrastructure, specifically in terms of digging the piping trenches, assisting with the fabrication of the central station and provision of the electrical infrastructure. They will also provide the electrical power to the project for the research period of one year so that free heating and cooling energy can be offered to the homeowner participants as an incentive to participate in the project.

B. Project Impact

With demonstrated viable economics, large scale deployment of a hybrid solar/geothermal energy microgrid system fueled by natural MN geothermal and solar energy resources will have a major impact on reducing the State's dependence on fossil fuels for heating and cooling with all the environmental benefits that entails. It will also very significantly cut the peak residential summer electrical demand, reducing the need for increased conventional power plant construction. The approach is not only applicable to new construction but can be retrofitted as well. With a "Conservation Utility" financing model, large-scale deployment of such an energy system infrastructure would have a major beneficial impact on the MN economy in terms of job creation and retention.

C. Time

The project will take 2.5 years to execute. The first 16 months will be used to build the houses, install and commission the microgrid. The next 12 months will be used for data collection with the final 2 months for analyzing the data, writing the final report and converting the microgrid to commercial operation. The project funding is required to purchase the necessary components and equipment for the microgrid principally including the solar thermal collectors, heat pumps, piping, manifolds, tanks and additional instrumentation (the existing HESS II instrumentation system will be used as the baseline). Funding also is needed to pay for researcher and staff time and for contractors to install the piping in the trenches.

D. Long-Term Strategy (if applicable)

This project is a precursor to a full deployment of a renewable energy based combined cooling, heating and power (CCHP) demonstration microgrid that has been approved conceptually for deployment in Rochester by the RPU board. Funding for implementing the full microgrid including electrical power generation at a meaningful demonstration scale (~100kWe) is being sought through Federal and other channels.

Project Manager Qualifications and Organization Description

The Principal Investigator (PI), Dr Louise F. Goldberg has B.Sc, M.Sc and Ph.D degrees in mechanical engineering. She has had 28 years experience conducting academic and commercial research in the fields of energy conservation and energy systems engineering having been the Principal Investigator (academic) or Manager/Director (commercial) on over 30 research projects. Her specific experience is as follows:

2002 - present: *Director, Building Physics and Foundations Research Programs, University of Minnesota: direct research programs in energy systems engineering and building physics.*

1996 - present: Principal, Lofrango Engineering: Own and operate engineering research and development consultancy specializing in intellectual property development.

1995 - present: *Senior Research Associate, College of Design, University of Minnesota: supervise graduate students, conduct sponsored research.*

1995 - 1996: Senior Vice President for Research and Development, Greengrove Corporation: Responsible for intellectual property development, design, construction and operation of pilot plant

1990 - 1995, 2005 - present: Member, Graduate Faculty, University of Minnesota: supervise graduate students

1987 - 1995: Research Associate, Underground Space Center, University of Minnesota: supervise graduate students, conduct sponsored research.

1981 - 1987: Research Fellow, Underground Space Center, University of Minnesota: conduct sponsored research.

1981: Associate Scientist, Underground Space Center, University of Minnesota: conduct sponsored research.

1980: Research Assistant, Underground Space Center, University of Minnesota: conduct sponsored research.

1979 - 1980: Junior Lecturer, School of Mechanical Engineering, University of the Witwatersrand: lecture undergraduate students in Fluid Mechanics, Thermodynamics and Engineering Design

Amongst the research projects carried out by the PI are two that were funded by the LCMR during the period 1981-85, namely, the “Solar/Earth Sheltered Housing Demonstration Program” and the development of computerized design analyses for energy efficient housing. More recently, the PI has carried out intensive research on renewable energy based building heating, cooling and power systems including a closed-loop solar-photovoltaic / hydrogen / fuel cell building combined heat and power demonstration system as well as a Hybrid Energy Systems Study (HESS) combining geothermal source/sink thermal energy, heat pumps and renewable or waste heat from sources such as solar thermal, cogenerated fuel cells or gray water heat recovery.

The proposed research project will be carried out by a partnership including the Building Physics and Foundations Research Programs, College of Design, University of Minnesota (Twin Cities); the University of Minnesota, Rochester, and the Rochester Public Utilities (largest municipal utility in Minnesota) . This partnership has been in existence for a number of years and recently successfully completed the HESS project referred to above.

Project Budget

IV. TOTAL PROJECT REQUEST BUDGET

BUDGET ITEM	AMOUNT	% FTE
Personnel: Salary and fringe benefits for 2.5 years Louise F. Goldberg, Ph.D(Eng), Principal Investigator - fringe = 24.2% of total	$ 126,820	30%
Hal H. Ottesen Ph.D, Co-Principal Investigator - fringe = 24.2% of total	$ 77,775	18%
James P. Licari Ph.D, Co-Principal Investigator - fringe = 5.9% of total	$ 40,304	13%
Contracts: Haley Comfort Systems (or similar) for installation of below-grade geothermal heat exchange tubing, drilling and fitting 4 vertical geothermal wells and rough-in of tubing to microgrid homes and central station	$ 26,200	
Equipment/Tools: 4 high performance custom design heat pumps - HVAC equipment for homes in microgrid	$ 36,000	
20 kW of evacuated tube solar thermal collectors - provides space heating source for microgrid	$ 50,000	
Central station stratified thermal storage system - stores solar heat for use on cloudy days and at night	$ 25,000	
Piping, pumps and other manifolding equipment - to connect all the microgrid system components together	$ 55,350	
Instrumentation - to monitor and report performance of microgrid in real time and publish data on the web (excluding computers that will be provided)	$ 25,000	
Polypropylene glycol (food grade) - environmentally safe heat exchange fluid	$ 23,000	
Heavily isnulated above-grade central station - to house the thermal storage system and associated equipment	$ 62,500	
Consumable supplies - solder, propane, paper, lab supplies	$ 4,000	
Other: In-state travel - return travel for PI from home in Minneapolis to Rochester (115 trips of 165 miles each over 2.5 years), plus in-city travel for purchase of supplies (115 trips of 12 miles each over 2.5 years reimbursable at Federal IRS mileage rate)	$ 12,222	
TOTAL PROJECT BUDGET REQUEST TO LCCMR	$ 564,170	

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT
In-kind Services During Project Period: Provided by Roch. Public Utilities	
Location of developer to build 3-4 house microgrid	$ 1,100
Liason with developer to mesh construction of houses with the project schedule	$ 4,400
Find homeowners to participate in the project and select participants	$ 2,200
Offer incentives to attract particpating homeowners including electrical power to run HVAC plant in all houses for 12 months	$ 3,456
Liason with homeowners to address their concerns during the project	$ 5,280
Install electrical power distribution infrastructure in the central station	$ 1,100
Provide separately metered power connection to heat pumps and associated equipment in 3-4 house	$ 1,000
Excavation, backfilling and surface finishing of all piping trenches	$ 6,240
Staff time and equipment to assist project team in building microgrid	$ 7,400
Provide electrical power to central station for project duration	$ 540
Equipment maintenance during project	$ 6,600
Staff time to develop rate structure and implementation policy for converting the experimental microgrid to a revenue-producing permanent, installation including definition of metering hardware	$ 7,360
Assist in removal of experimental equipment	$ 550
TOTAL IN-KIND SERVICES	$ 47,226

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