



Environment and Natural Resources Trust Fund

2022 Request for Proposal

General Information

Proposal ID: 2022-028

Proposal Title: Advanced Aquifer Heat Transfer Technology for Buildings

Project Manager Information

Name: Patrick Hamilton

Organization: Science Museum of Minnesota

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Project Basic Information

Project Summary: Pilot project to document the efficacy of new, advanced aquifer heat transfer technology that uses the earth to reduce dramatically the costs and carbon emissions of heating and cooling buildings.

Funds Requested: \$606,000

Proposed Project Completion: June 30 2024

LCCMR Funding Category: Air Quality, Climate Change, and Renewable Energy (E)

Project Location

What is the best scale for describing where your work will take place?

Region(s): Metro

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project and In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Technology that takes advantage of the stable year-round temperature of the earth at depth to heat and cool buildings has long existed but has seen small market penetration in Minnesota because of its high upfront costs. Large numbers of wells and great lengths of tubing are needed to accommodate the inherently slow transfer of heat by conduction between the fluid in the tubing and the solid earth.

Darcy Solutions – a Minnesota-based start-up company employing technology developed through University of Minnesota research – has developed a novel approach to ground-source heating and cooling. Instead of relying on the sluggish process of conduction, Darcy Solutions drills wells into aquifers and installs heat exchangers in the groundwater to utilize the much more efficient convective flow of water to transfer heat. No extraction of groundwater occurs. A closed loop system together with heat exchangers transfer heat so efficiently that the number of wells that need to be drilled is one twentieth of that required by conventional ground-source heating and cooling systems.

This technology warrants much more visibility and discussion since it could play a significant role in reducing greenhouse gas emissions from buildings, one of the state's largest sources of greenhouse gases.

What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.

As electricity generation in Minnesota shifts from coal toward more wind and solar, electricity is becoming the low-carbon, even zero-carbon energy source of choice for the heating and cooling of buildings. Electric-powered ground-source heat pumps are the most energy efficient and environmentally friendly way to pump heat into buildings in winter and remove it in summer, making the most efficient use of this clean electricity.

The Science Museum seeks funding to install several Darcy Solutions wells in Science Park, its future outdoor environmental innovation exhibit space, and tie these wells into its HVAC system to quantify, document and demonstrate how both new and existing buildings could benefit from this new approach to using the earth to heat and cool buildings.

Since 2015, the Science Museum's use of heat recovery chillers to reuse heat energy previously rejected from its building has reduced its purchases of hot water by 65%, slashed its carbon emissions by one third and saved it \$300,000 annually. The museum now seeks to demonstrate how advanced aquifer heat transfer can further dramatically reduce the financial and environmental costs of heating and cooling buildings, while also stewarding the prudent use of the state's increasingly clean electricity.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

Contrast and compare the first costs and operating costs of the Science Museum's advanced aquifer heat transfer technology to traditional ground-source heating and cooling and conventional HVAC so as to quantify its financial advantages and encourage more widespread adoption in Minnesota.

Quantify how the Science Museum's application of advanced aquifer heat transfer technology reduces its greenhouse gas emissions, and by extension how broader employment of this technology could reduce the carbon footprint of buildings across Minnesota.

Greatly expand the visibility and understanding of advanced aquifer heat transfer technology by student, general public, professional, opinion leader, utility, and policymaker audiences.

Activities and Milestones

Activity 1: Installation of advanced aquifer heat transfer well field in Science Park - the Science Museum's outdoor environmental innovation exhibit space

Activity Budget: \$285,000

Activity Description:

Utilize well logs and geological information from the existing Science Park well and surrounding area wells to develop the design of individual wells and the integrated field loop. Well designs will consider hydrogeology to determine type of well, size and depth, and placement of heat exchangers within each well. The integrated field loop design will consider the spatial relationship of the wells and their orientation relative to the natural flow direction of the aquifer within the river basin geology.

Specify the locations for several advanced aquifer heat transfer wells within the Science Museum's Science Park. These locations will also consider the potential placement of future wells to provide additional heat exchange capacity for the Science Museum. Drill and develop each well. The development process allows the groundwater to freely flow from the well for a period of time (eg, 12-24 hours) to clean drilling materials and the fines and sediment from the pore space of the surrounding formation.

Complete the wells and place the integrated Darcy system components, including the heat exchangers, into each well. Dig/bore piping to make the lateral connections from each well into the header in the Science Museum's main mechanical room.

Activity Milestones:

Description	Completion Date
Evaluate well logs of the existing Science Park well and design wells and field loop	September 30 2022
Specify locations of for the advanced aquifer heat transfer wells	September 30 2022
Drill and finish each of the wells.	February 28 2023
Install system components, including heat exchangers, into the wells	March 31 2023
Connect wells to mechanical room	April 30 2023

Activity 2: Tie the Science Park advanced aquifer heat transfer well field into the Science Museum's HVAC system

Activity Budget: \$285,000

Activity Description:

Tie-in of the new advanced aquifer heat transfer system shall begin once the header from the new well field has been installed within the Science Museum's main mechanical room and linked to the facility's existing HVAC heating and cooling loads. The facility's loads primarily consist of the skin load and the ventilation loads.

Work will include the placement of major equipment components including coils and heat exchangers such that the loads are reduced on existing HVAC systems. Once major components are in place, piping will be installed to connect the HVAC components to the new geothermal header. The museum's building automation system will be upgraded to include energy efficiency sequences to maximize the integration of the advanced aquifer heat transfer well field with the HVAC equipment to ensure further increases in the efficiency of the overall system.

After all installation activities are completed, the entire system will be commissioned to ensure that building automation

system and HVAC equipment are operating in combination correctly, and that anticipated heating and cooling load reductions are being realized. The final completion of this construction will result in a significant reduction in energy use by the facility and an associated reduction.

Activity Milestones:

Description	Completion Date
Purchase the header and other major equipment components	April 30 2023
Install header and other major equipment components	June 30 2023
Install interconnection piping	August 31 2023
Start up the system and proceed with commissioning	September 30 2023

Activity 3: Magnify visibility to student, general public, professional, opinion leader, utility, and policymaker audiences with a demonstration system at the museum.

Activity Budget: \$36,000

Activity Description:

The Science Museum will develop and deploy the following measures to expand awareness of and interest in advanced aquifer heat transfer technology:

Include presentations and behind-the-scenes tours of the system in the Sustainable Buildings 2030 Symposium for architects, engineers, building owners and financiers hosted annual by the museum in partnership with the University of Minnesota’s Center for Sustainable Building Research, Xcel Energy and the City of Saint Paul.

Integrate general public behind-the-scenes tours of the system into the museum’s many annual winter weekend science festivals.

Regularly share the information about the museum’s reductions in energy expenditures and carbon emissions via the museum’s many social media accounts.

Develop integrated presentations and behind-the-scenes tours for one-on-one engagement opportunities with professional groups visiting the museum specifically for first-hand experiences with advanced aquifer heat transfer technology.

Prepare an article for publication in the online journal Midwest Energy News Network.

Reach out to MPR’s Climate Cast about doing a story about the museum’s utilization of advanced aquifer heat transfer technology.

Activity Milestones:

Description	Completion Date
Produce social media posts describing progress/process of integrating advanced aquifer heat transfer into the museum.	December 31 2023
Develop presentations/tours for professional groups visiting the museum for first-hand experiences with the technology.	January 31 2024
Integrate general public behind-the-scenes tours of the system into the museum’s many annual winter weekend science festivals.	February 28 2024
Begin posting about energy expenditure and carbon emission reductions via the museum’s social media accounts.	March 31 2024

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Jimmy Randolph	Darcy Solutions	Jimmy Randolph, Ph.D. is the Chief Technology Officer for Darcy Solutions. Jimmy and his firm will oversee the design and construction of the well field and the placement of the heat exchangers into the finished wells.	Yes
Mark Rasmussen	Apex Facility Solutions	Mark Rasmussen, PE is the owner of Apex Efficiency Solutions, which delivers renewable energy and energy efficiency projects. Mark and his firm will oversee the design and construction of the interconnections between the Darcy Solutions well field and the museum's heat recovery chillers.	Yes

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this be funded?

Advanced aquifer heat transfer technology will be significant element of the Science Museum's carbon neutrality project, which seeks to demonstrate how buildings can cut carbon emissions by 50% by 2030 if not sooner and be carbon neutral by 2050 at the latest. The ongoing operation and maintenance of the Darcy Solutions system will be incorporated into the museum's facility management while the museum's efforts to disseminate information and insights about advanced aquifer heat transfer technology will be led by the Department of Global Change initiatives, within the museum's Center for Research and Collections.

Project Manager and Organization Qualifications

Project Manager Name: Patrick Hamilton

Job Title: Director, Global Change Initiatives

Provide description of the project manager's qualifications to manage the proposed project.

Patrick Hamilton is the Director of Global Change Initiatives at the Science Museum of Minnesota and a Fellow of the University of Minnesota's Institute on the Environment. Patrick led the team that in 2003 on the grounds of the museum designed and constructed Science House – one of the first net zero energy buildings in Minnesota. Patrick championed the Science Museum's advanced heat recovery project which since 2015 has reduced the museum's purchases of hot water by 65%, cut the museum's carbon dioxide emissions by one third, and saves the museum \$300,000 annually. Patrick now is leading the Science Museum's carbon neutrality project, which seeks to cut the museum's carbon emissions by 50% by 2030 if not sooner and achieve net zero carbon by 2050 at the latest. Patrick has been producing exhibits and programs about environmental issues for the Science Museum for 37 years.

Organization: Science Museum of Minnesota

Organization Description:

The Science Museum of Minnesota, founded in 1907, is located in downtown St. Paul. The museum's programs combine research and collection facilities, a public science education center, extensive teacher education and school outreach programs, and an Imax Convertible Dome Omnitheater to provide science education to our regional and national audience of more than a million people per year.

The museum's 70,000 square feet of exhibition space includes a 10,000-square-foot temporary exhibit gallery and five permanent galleries covering the topics of paleontology, physical science and technology, the human body, peoples and cultures of the Mississippi River, and the museum's collections. The Science Museum of Minnesota employs over 200 full and part time staff and is supported by more than 1,000 dedicated volunteers.

The museum is known for its in-house interactive exhibits, traveling exhibitions, and internationally distributed films. The museum was an early innovator in the use of live theater as an interpretive tool and continues to be a training ground for other museums wishing to include live programming. The museum provides innovative staff development programs for teachers throughout the region and science education outreach programs for students in all 87 of Minnesota's counties.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Project director		Manage and supervise all aspects of the project			26%	0.2		\$36,000
							Sub Total	\$36,000
Contracts and Services								
Darcy Solutions	Professional or Technical Service Contract	Supervise the drilling and finishing of wells to specifications. Supply heat exchangers for installation in the wells. Oversee the tying of the well field into the museum's main mechanical room. Work with HVAC contractor on integrating well field into museum's sequence of operation and commissioning the new system.				0		\$285,000
Apex Facility Solutions	Professional or Technical Service Contract	Oversee all contractors involved in tying well field into the museum's HVAC system, installing header and other equipment, refining the museum's revised HVAC sequence of operation and overseeing the commissioning of the new system.				0		\$190,000
							Sub Total	\$475,000
Equipment, Tools, and Supplies								
	Equipment	2 HVAC coils @ \$10,000 ea.	Exchange heat between Darcy Solution wells and museum's fresh air intake					\$20,000
	Equipment	Chiller heat exchanger	Exchange heat between Darcy Solution wells and museum's heat recovery chillers					\$20,000
	Equipment	Major equipment controllers	Manage interface between the Darcy Solutions wells and the museum's energy management system					\$5,000
	Equipment	1,000 feet of piping @ \$50/foot	Closed loop piping between Darcy Solution wells and museum's first floor mechanical room					\$50,000

							Sub Total	\$95,000
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
							Sub Total	-
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
							Sub Total	-
Other Expenses								
							Sub Total	-
							Grand Total	\$606,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
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Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	-
Non-State				
			Non State Sub Total	-
			Funds Total	-

Attachments

Required Attachments

Visual Component

File: [1fc09937-6d3.pdf](#)

Alternate Text for Visual Component

This graphic summarizes the challenges and opportunities of geothermal in Minnesota and outlines how an advance aquifer heat transfer demonstration project at the Science Museum would accelerate awareness and adoption of this new approach to using the earth to heat and cool buildings....

Optional Attachments

Support Letter or Other

Title	File
Science Museum letter in support of its Advance Aquifer Heat Transfer Technology for Buildings proposal	68ce30a4-056.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have potential for royalties, copyrights, patents, or sale of products and assets?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No

EXPANDING AWARENESS OF ADVANCED AQUIFER HEAT TRANSFER - A MINNESOTA ENERGY INVENTION

CHALLENGE

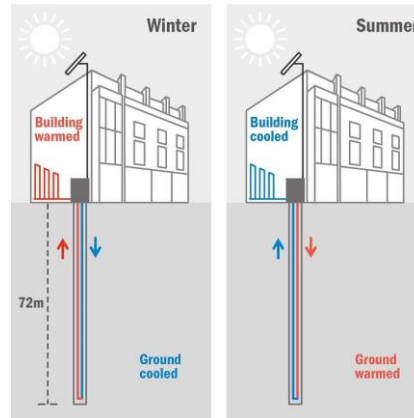
Heating and cooling is a major expense for all Minnesota building owners.

OPPORTUNITY

Using the stable temperature of the earth at depth is a highly efficient way to heat and cool buildings.

CHALLENGE

Conventional geothermal has high upfront costs. Many wells and long lengths of tubing are needed for the slow **conduction** of heat between the fluid circulated within tubing and the solid earth.



OPPORTUNITY

Greatly expand its visibility to student, general public, professional, opinion leader, utility, and policymaker audiences by **installing a demonstration system at the Science Museum of Minnesota.**

CHALLENGE

Awareness of this new approach to geothermal is sorely lacking, inhibiting its more rapid adoption and **hindering economic and employment opportunities for Minnesotans.**

OPPORTUNITY

A Minnesota start-up drills wells into aquifers and installs heat exchangers that use the far more effective **convective** flow of heat to reduce the wells that need to be drilled to **one twentieth** of conventional geothermal.