Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-394

Proposal Title: Assessing Wind Curtailment Reduction Potential via Hydrogen Production

Project Manager Information

Name: Aditya Ranade

Organization: Aerio Technologies

Office Telephone: (216) 375-4842

Email: aditya@aeriotech.com

Project Basic Information

Project Summary: This project will assess the potential for renewable hydrogen in Minnesota as a means to store wind energy, reduce its curtailment and decarbonize the natural gas supply

Funds Requested: $751,000

Proposed Project Completion: 2022-12-31

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?

Statewide

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

Statewide

When will the work impact occur?

In the Future

Narrative

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

The installed wind energy capacity in Minnesota is 3.8 GW with an additional 500 MW capacity projected to be installed in 2020. Wind energy accounted for 18% of Minnesota's electricity generation in 2019. However, about 8% of the wind energy produced in Minnesota is currently curtailed due to the lack of transmission lines. In addition, the average capacity factor for wind production in Minnesota was 33% in 2018, somewhat below the national average of 35%, in part due to production during non-peak hours. Best in class capacity factor for a single state was 41% for onshore wind production, in Kansas in 2018 with many projects exceeding 50%, which Minnesota must aspire to meeting its decarbonization goals for the power sector. Converting excess wind energy to renewable hydrogen will improve the economics of wind for the state. If renewable hydrogen can be incorporated in the natural gas pipelines in small amounts or combined with captured CO2 from ethanol production to make natural gas, it can be a promising way to decarbonize the natural gas supply. For renewable hydrogen to play this role in the energy sector, a statewide assessment of both its technical potential land economic viability is essential.

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.

We propose to undertake a statewide assessment of how much renewable hydrogen can be produced at current (3.8 GW), planned (4.3 GW) and future (20 GW) installed wind capacity assuming a capacity factor of 50%. We also aim to estimate the cost of hydrogen production as a function of wind farm size. In addition, we seek to determine maximum possible incorporation of hydrogen in existing natural gas infrastructure without impacting pipeline physical integrity and combustion properties. Lastly, we aim to determine the potential for combining the hydrogen produced with captured CO2 from ethanol facilities to make natural gas using both economic and geo-spatial analysis.

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?

By reducing curtailment of wind energy, the area used for wind energy produced will be optimized leading to conservation of land for protecting waterways, agricultural production and habitat protection for birds. Reduction in greenhouse gas emissions associated with natural gas sector in Minnesota will go along way towards decrabonization of the energy sector

Activities and Milestones

Activity 1: Quantify the Potential for Hydrogen Production from Reduced Wind Energy Curtailment

Activity Budget: $300,000

Activity Description:
: In this activity, Aerio Technologies will determine how much hydrogen can be produced by using wind energy that would otherwise be curtailed because of lack of transmission capacity and/or production during periods of low demand. Aerio Technologies will create a database of all utility scale wind energy projects in MInnesota at current and planned levels of deployment of 3.8 GW and 4.3 GW. In addition, Aerio Technolgies will create a hypothetical database assuming aggressive deployment of (20 GW by 2030. Aerio Technologies will survey a statistically significant number of existing projects in Minnesota for estimating typical capacity factors and curtailment rates. Aerio Technolgies will also survey installations in other U.S. states to determine the best onshore capacity factors and curtailment rates. By using the difference between the existing and ideal scenarios, the amount of wind energy available for hydrogen production would be determined. Best in class commercially available electrolyzer designs would be used to estimate the amount of hydrogen produced and the cost of production, if all excess wind energy was used towards this.

Activity Milestones:

Description	Completion Date
Renewable hydrogen production cost estimate by wind farm size	2021-12-31
Quantify statewide potential for hydrogen production using wind energy	2021-12-31
GIS map of wind farms and hydrogen volume	2022-07-31

Activity 2: Determine the Feasibility of Hydrogen Fuel for Combustion Applications

Activity Budget: $251,000

Activity Description:
: In this activity, the University of Minnesota Department of Mechanical Engineering will determine the impact of hydrogen incorporation in natural gas on combustion properties for various applications (e.g. residential and commercial heating, industrial heating, power generation). The range of hydrogen in the natural gas mix will range up to about 5% and be informed by the work conducted under Activity 1. This activity will be accomplished through computer simulations of different combustion devices using software available at the university. The decision of what devices to model will be made through review of literature and conversation with Minnesota stakeholders including utility companies and other natural gas users. Models of gas turbine combustors, heaters, and other users of natural gas will be constructed and used to determine changes in flame speed, capacity, among other properties for these devices. The primary outcome of the activity will be to determine how much hydrogen gas can be incorporated in the natural gas mix in Minnesota. This estimate will be checked with combustion appliance manufacturers as part of the activity.

Activity Milestones:

Description	Completion Date
Perform literature review on hydrogen tolerance and choose combustion devices to model	2021-12-31
Determine maximum recommended hydrogen levels for blending into natural gas supply	2022-03-31
Confirm recommended hydrogen levels with device manufacturers and publish results	2022-06-30
Model at least four combustion devices to determine hydrogen tolerance	2022-12-31

Activity 3: Quantify the Potential for Hydrogen Methanation with Carbon Dioxide sourced from Ethanol production

Activity Budget: $200,000

Activity Description:

In this activity, Aerio Technologies will survey Ethanol production plants in the state of Minnesota including determining the carbon dioxide emissions for each plant. By assuming a state of the art commercially deployable carbon capture and scrubbing equipment, the volume and cost of carbon dioxide captured would be determined. As the last step, potential for natural gas production by combining hydrogen from wind curtailment reduction (Activity 1) and carbon dioxide captured from Ethanol production will be assessed. The choice of chemical pathway and catalyst would be determined by interviewing experts in academia and chemical industry.Finally, the total impact of Hydrogen production and usage on carbon emissions from the Natural Gas Sector in MInnesota would be assessed under two scenarios a. Usage for hydrogen injection in natural gas pipelines b. Combined usage including hydrogen injection in natural gas pipelines and as natural gas produced by methanation

Activity Milestones:

Description	Completion Date
volume potential and cost for methanation and GIS location with existing natural gas pipelines	2022-12-31
Cost of CO2 capture by size of Ethanol production	2022-12-31
GIS location database of ethanol production and wind farms	2022-12-31

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Dr. William Northrop	University of Minnesota	Lead activity 2 in determining combustion of hydrogen fuel for different applications	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?

Results of the analysis will be shared with electrical utilities, gas utilities, wind energy and ethanol project developers in the state so that they plan facilities for hydrogen production, injection of hydrogen in natural gas pipelines and hydrogen methanation. Results of the analysis will also be provided to Minnesota Department of Commerce and Minnesota Public Utilities Commission so they can review utility integrated resource plans in light of these possible solutions.

Project Manager and Organization Qualifications

Project Manager Name: Aditya Ranade

Job Title: Partner

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

Dr. Aditya Ranade has a Ph.D. (Maromolecular Science) and has 14 years of experience in commercializing a variety of technologies in the energy sector. His most recent job prior to Aerio Technologies was leading global smart grid R&D for 3M, where his team developed an underground electrical distribution monitoring system including sensors, edge computing device and embedded software. This system has been deployed at a number of utilities in North America, South America and Asia. Prior to 3M, he has worked for Saint-Gobain developing solar panel materials and for Lux Research analyzing solar and green building industries.

Organization: Aerio Technologies

Organization Description:

Aerio Technologies provides decision analytics software and services for renewable natural gas and renewable hydrogen production

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Northrop (Faculty)		Lead activity 2			26.74%	0.16		$36,000
Zarling (Research Scientist)		Lead scientist on activity 2			26.74%	0.92		$103,000
Research Assistant		Assist on activity 2			41%	1		$109,000
Ranade (Installer Survey)		Synthesize analyses for all activities, project management			25%	0.4		$100,000
Arend (Chemical Engineering)		Lead chemical engineering analyses for activities 1 and 3			25%	0.8		$200,000
Rinn (GIS Analysis)		Lead GIS analysis for activities 1 and 3			25%	0.8		$200,000
							Sub Total	**$748,000**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Equipment	Computers and video processing supplies	analyze combustion data and simulate engine performance					$3,000
							Sub Total	**$3,000**
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	**$751,000**

Classified Staff or Generally Ineligible Expenses

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

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	University of Minnesota	Cost share for lost indirect expenses from University of Minnesota	Pending	$120,000
			Non State Sub Total	**$120,000**
			Funds Total	**$120,000**

Attachments

Required Attachments

Visual Component

File: 9bc8f080-e92.pdf

Alternate Text for Visual Component

GIS analysis of dairy biomethane production including distance to nearest pipeline, cost and greenhouse gas reduction- examples in Minnesota and Maryland

Optional Attachments

Support Letter or Other

Title	File
University of Minnesota Support Letter	2ef46ceb-409.docx

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have patent, royalties, or revenue potential?

No

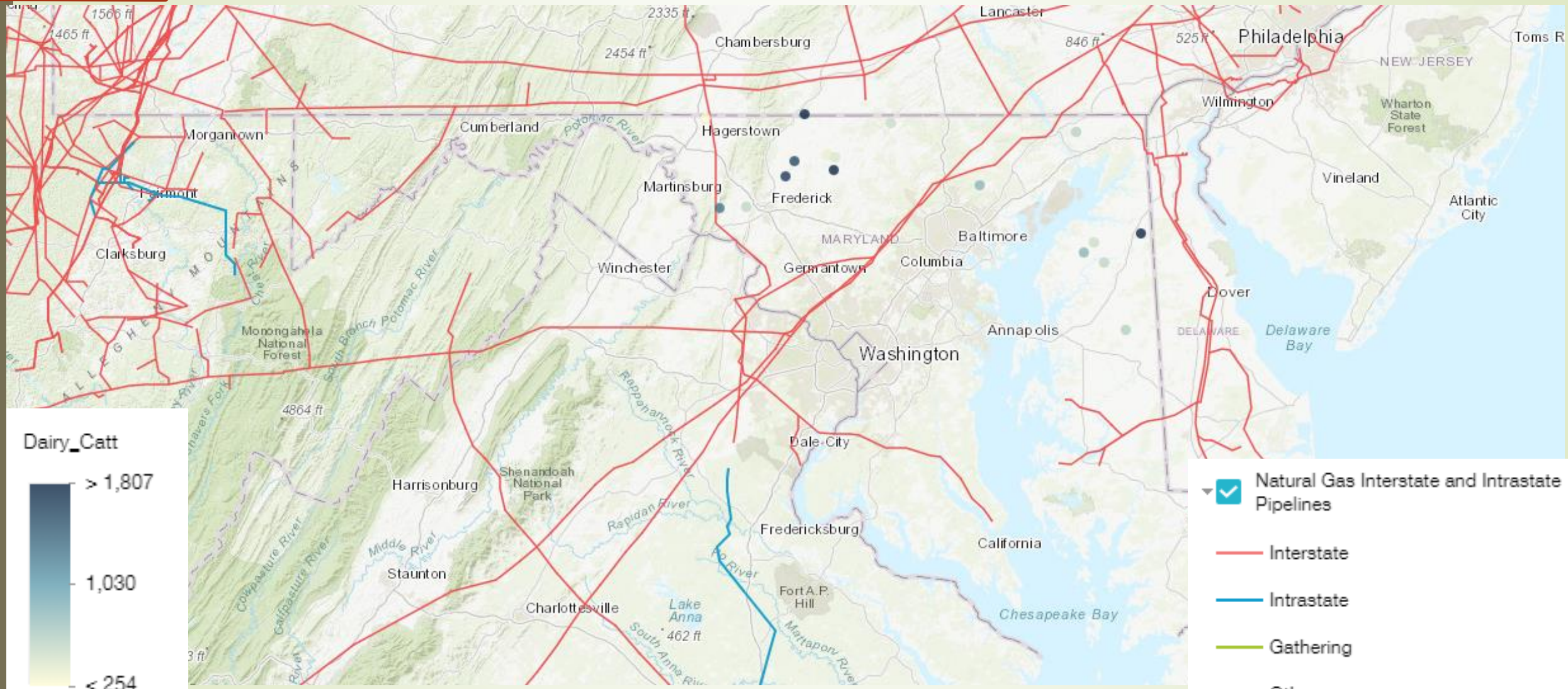
Does your project include research?

Yes

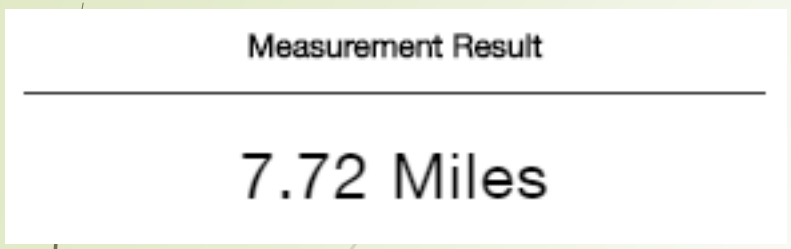
Does the organization have a fiscal agent for this project?

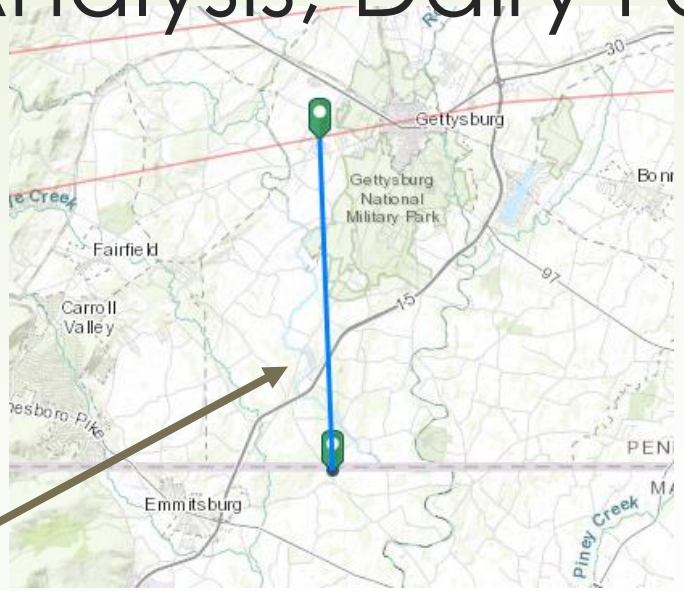
No

Source Visualization for Dairy Farms in Maryland

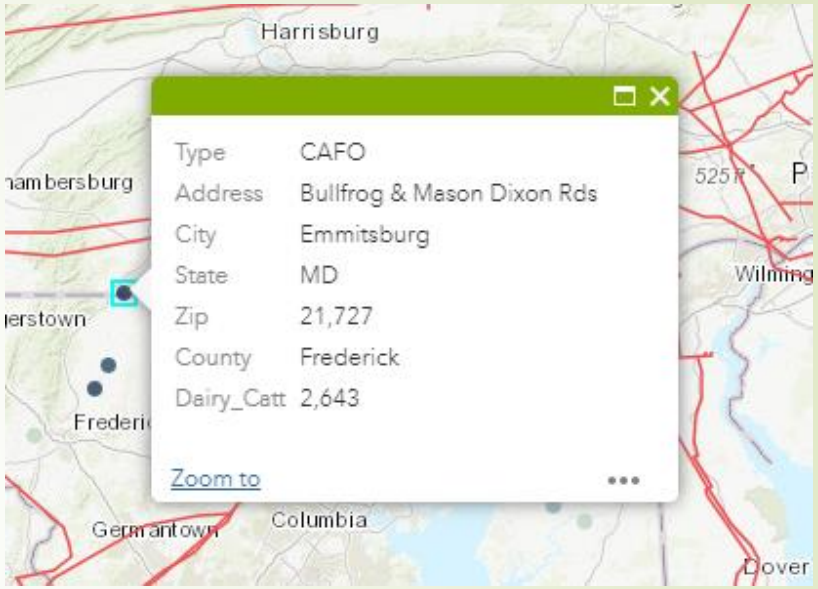


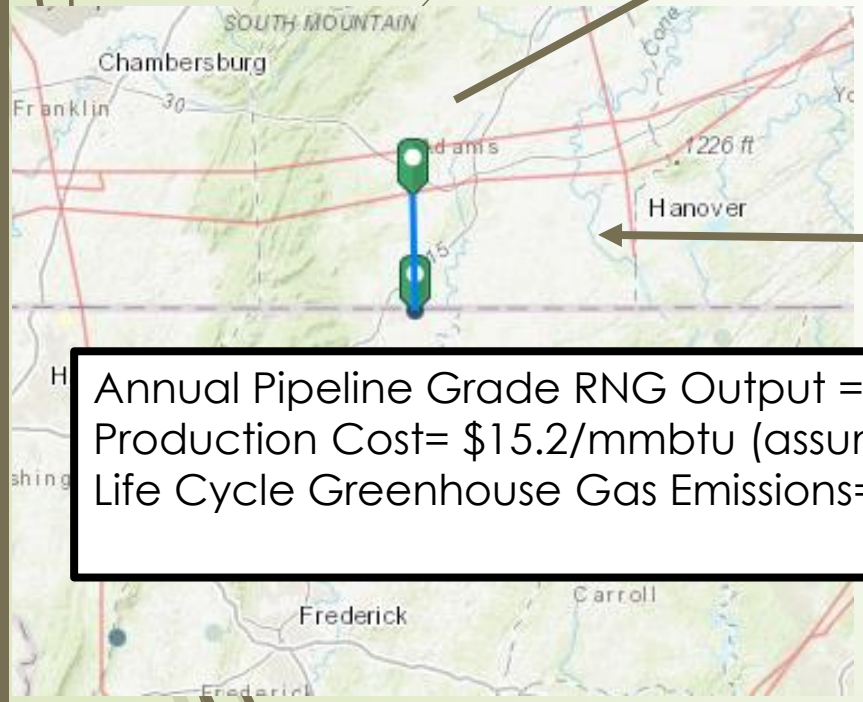
Cost and LCA Analysis, Dairy Farm, Emmitsburg, MD



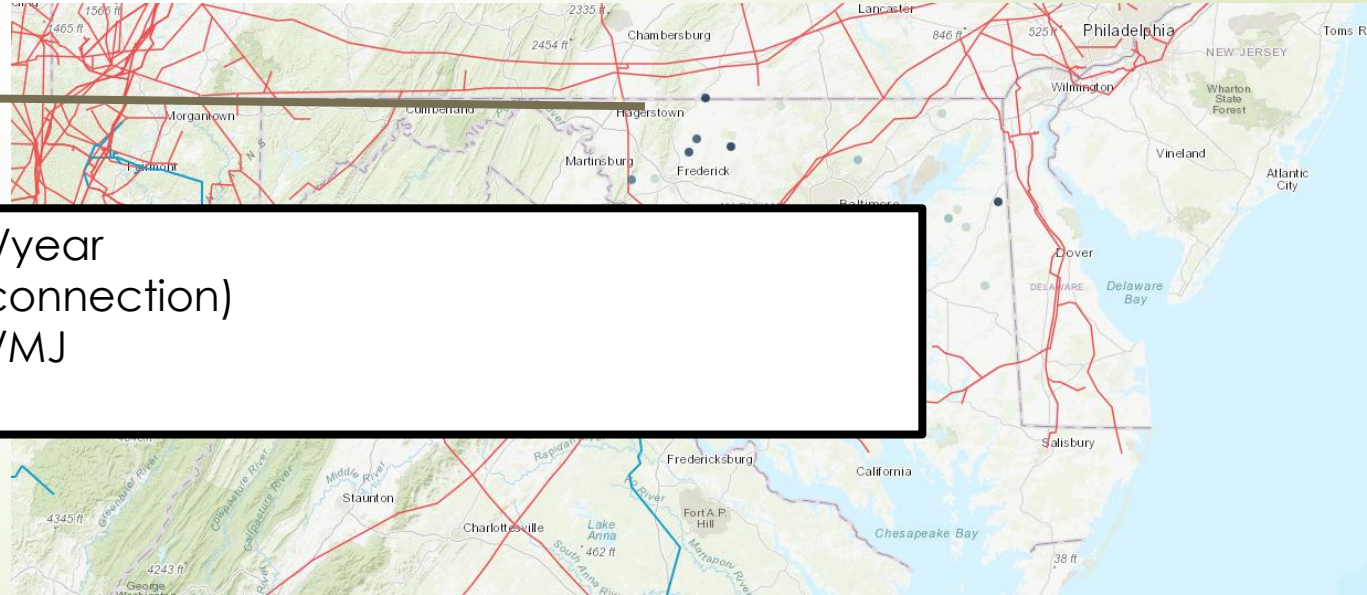


ZOOM





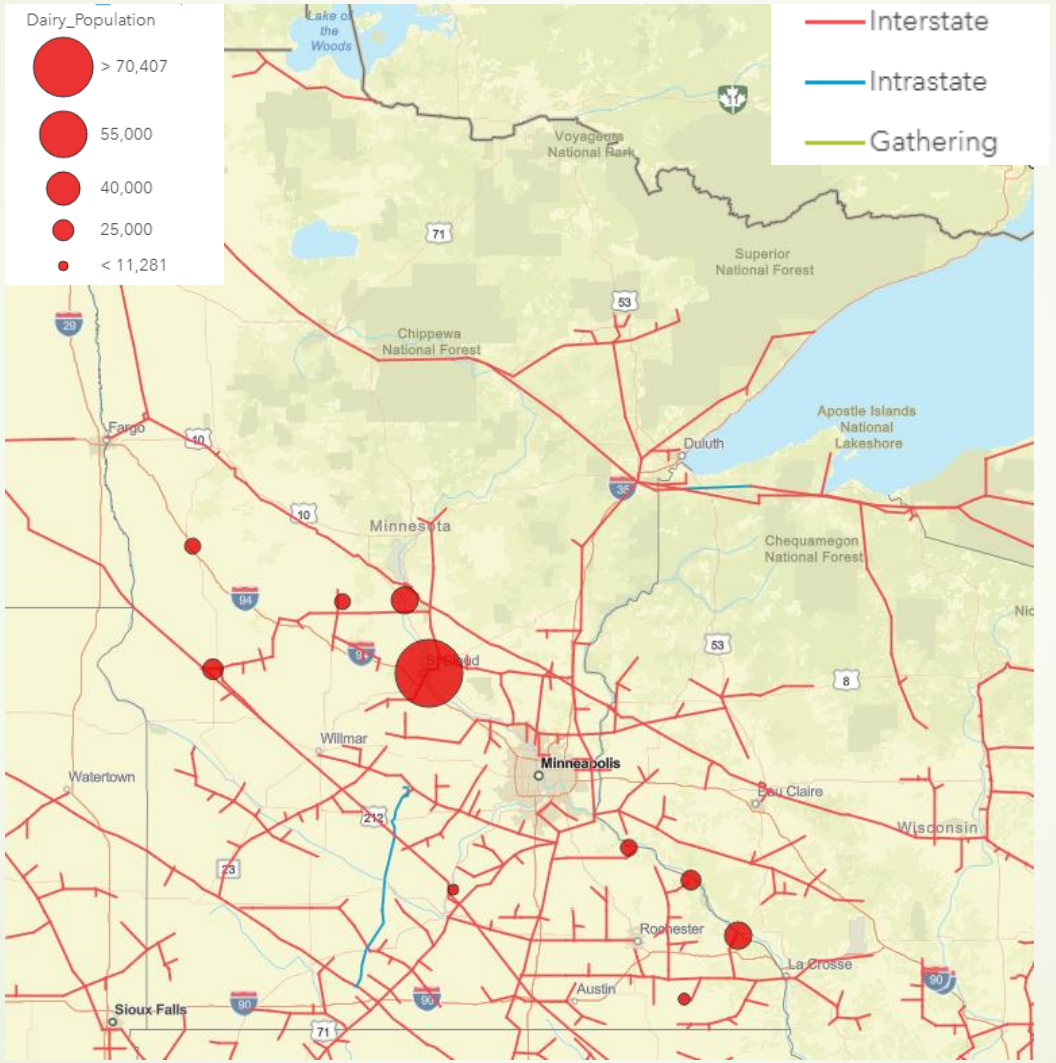
ZOOM



Annual Pipeline Grade RNG Output =45,500 mmbtu/year
Production Cost= $15.2/mmbtu (assuming pipeline connection)
Life Cycle Greenhouse Gas Emissions= -228 gCO2e /MJ

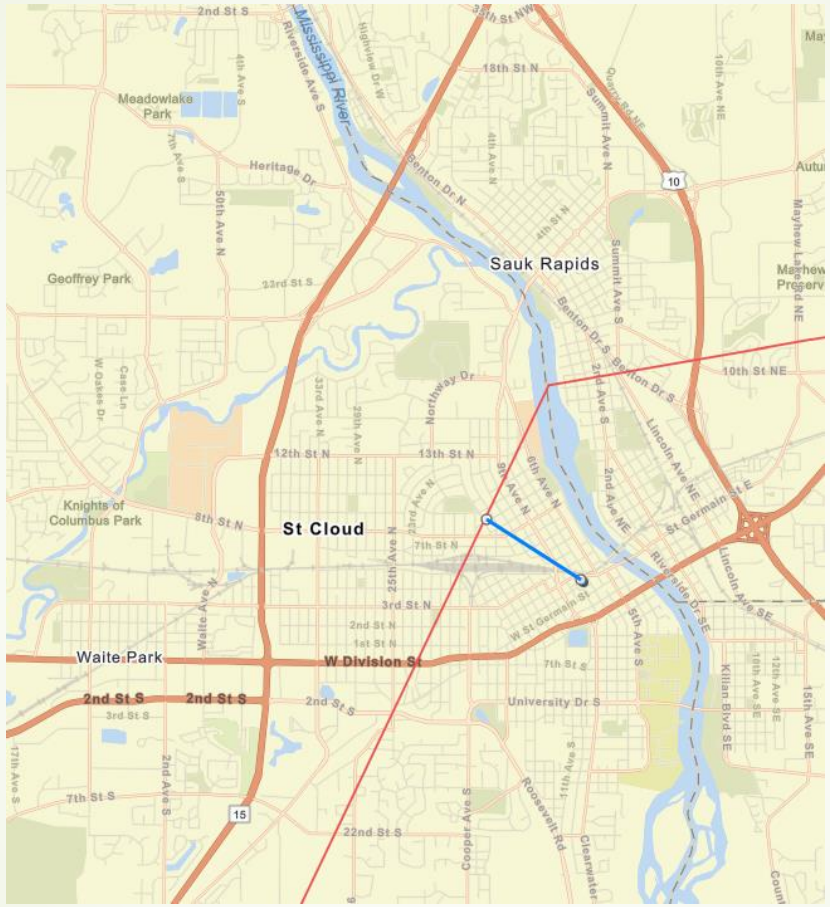
Source Visualization for Dairy Cattle in Minnesota: Top 10 Counties

Potential for RNG from Top 10 Dairy Counties: 7 bcf/year



Cost and LCA Analysis, Dairy Cattle, Stearns County

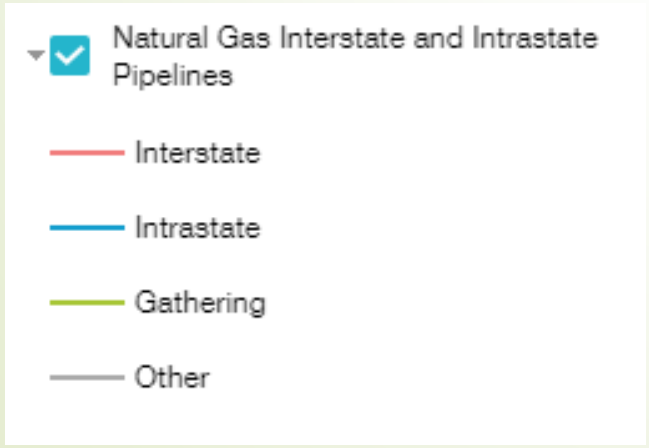
Distance to Pipeline from Aggregation Point: 1 mile



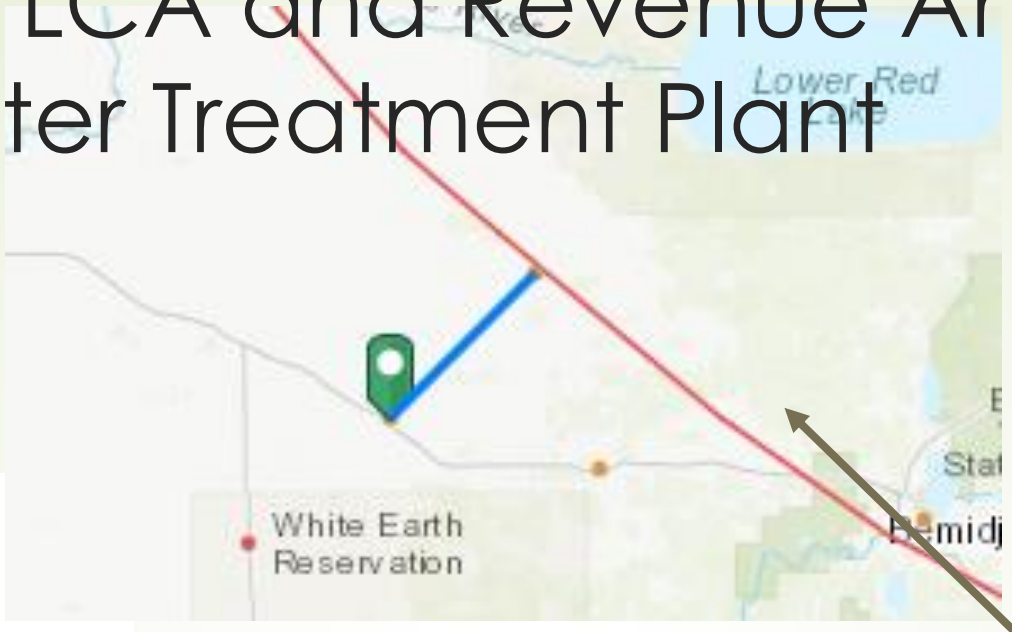
Annual Pipeline Grade RNG Output =1,156,320 mmbtu/year
Production Cost= $5.56/mmbtu (assuming pipeline connection)
Life Cycle Greenhouse Gas Emissions= -322 gCO2e /MJ

Source Visualization for Wastewater Treatment Plants

Potential for RNG from Landfills: 2 bcf/year



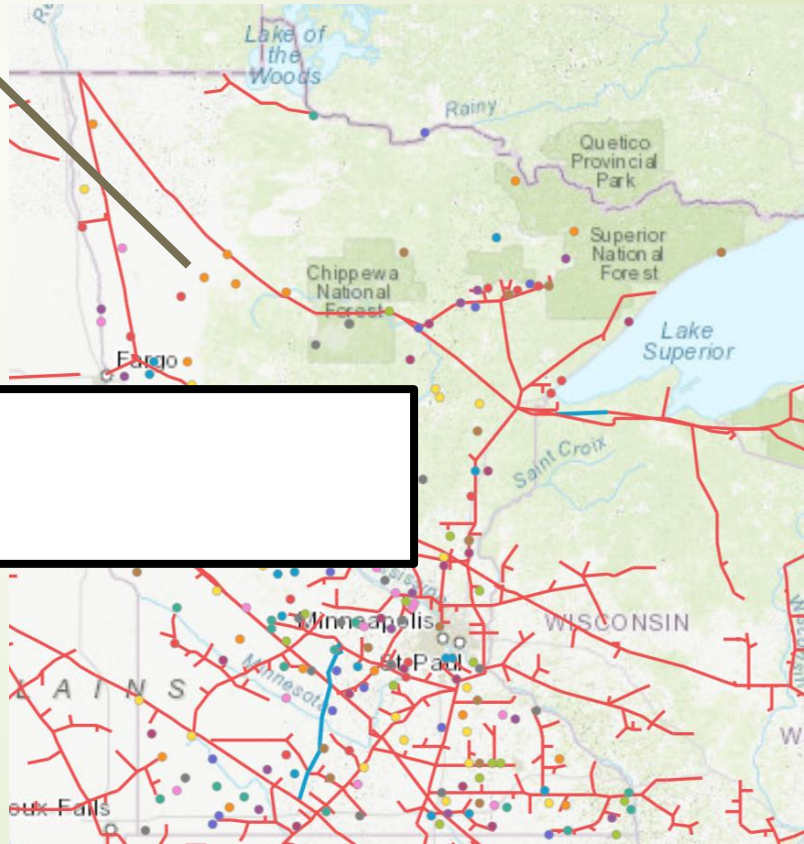
Cost and LCA and Revenue Analysis, Fosston Wastewater Treatment Plant



SOURCE_ID	MN0022128
EPA_SYSTEM	ICP
REGISTRY_ID	110,009,000,000.00
STATUTE	CWA
CWP_NAME	FOSSTON
CWP_STREET	TSHP RD 27 T148N R40W SEC 33
CWP_CITY	FOSSTON
CWP_STATE	MN
CWP_STATE_DISTRICT	
CWP_ZIP	56542
CWP_COUNTY	Polk
CWP_EPA_REGION	
CWP_STATUS	
CWP_INDIAN_CNTRY_FLG	
CWP_TRIBAL_LAND_CODE	
CWP_PERMIT_STATUS_CODE	EFF
CWP_PERMIT_STATUS_DESC	Effective
CWP_PERMIT_TYPE_CODE	NPD
CWP_PERMIT_TYPE_DESC	NPDES Individual Permit
CWP_EXPIRATION_DATE	November 29, 2018
CWP_FACILITY_TYPE_INDICATOR	POTW
CWP_MAJOR_MINOR_STATUS_FLAG	N

Measurement Result

15.7 Miles



Annual Pipeline Grade RNG Output= 867,240 mmbtu/year
Production Cost= $6.38/mmbtu
Life Cycle Greenhouse Gas Emissions= 5 gCO2e/MJ