Environment and Natural Resources Trust Fund
2020 Request for Proposals (RFP)

Project Title: **ENRTF ID: 189-E**

Remove Airborne Contaminants from Animal Production Facilities

Category: E. Air Quality, Climate Change, and Renewable Energy

Sub-Category:

Total Project Budget: $ 585,000

Proposed Project Time Period for the Funding Requested: June 30, 2023 (3 yrs)

Summary:

Develop and evaluate innovative non-thermal plasma-based technologies for removing airborne biological and chemical contaminants from animal production facilities; protect human and animal health and environment.

Name: Roger Ruan

Sponsoring Organization: U of MN

Job Title: Professor

Department: College of Food, Agricultural and Natural Resource Sciences

Address: 1390 Eckles Ave.

St. Paul MN 55108

Telephone Number: (612) 625-1710

Email ruanx001@umn.edu

Web Address:

Location:

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Harmful impacts of biological and chemical airborne contaminants on human health and the environment; strategy to reduce or eliminate these contaminants.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base	
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency	
_____ Capacity Readiness	_____ Leverage		_____ TOTAL	_____%

PROJECT TITLE: Removing airborne contaminants from animal production facilities

I. PROJECT STATEMENT

Minnesota is a leading livestock producing state. Livestock and its products account for about half of the state's farm income. A major concern with livestock farming is the airborne pollutants including pathogenic microorganisms such as *Salmonella*, *Streptococcus,* and avian influenza virus, and odorous and acid rain causing chemicals such as ammonia and hydrogen sulfide. This project will be focused on the development and evaluation of innovative non-thermal plasma-based technologies and their use in reducing or eliminating airborne biological and chemical contaminants from animal production facilities. The successful development of the proposed technology is expected to help protect human and animal health and reduce greenhouse emissions. The project addresses ***Priority*** *E: Air Quality, Climate Change, and Renewable Energy*.

Avian influenza virus (AIV) or bird flu caused by AIV is incredibly disruptive to the regional poultry industry due to massive culling of infected birds, and restrictions placed on poultry meat exports. In 2015 a regional outbreak in Minnesota resulted in an estimated $647.2 million in economic damage and affected over 2,500 jobs. Some AIV strains can cause infections in humans, with mortality rates of 50% among infected individuals in some outbreaks. Cases of human infection with AIVs have been reported globally although it is quite rare in the US. US Centers for Disease Control and Prevention speculates that poultry facilities could spread bird flu to humans through a number of pathways (See visual attachment). ***Other airborne pathogens*** in poultry barns and hog farms, which have potential to harm humans, include *Salmonella*, *Staphylococcus*, *Streptococcus*, *Mucor*, *A. niger*, *Scopulariopsis*, and many others.

Controlling ***nuisance odors*** from animal facilities such as ammonia and hydrogen sulfide (H_2S) is another major area of concern. Odor-related issues range from mild complaints from neighboring communities to lawsuits resulting in costly stoppages in farming operations. Minnesota, as a leading producer of eggs and turkeys as well as hogs, must find a solution to these economic, environment, and health problems.

This project is built on our expertise and experience in developing ozone and non-thermal plasma (NTP) processes for AI virus inactivation, odor reduction, and hazardous emission control. These techniques are based on non-thermal plasma physics and chemistry and are proven methods of microbial control and hazardous gaseous decomposition. A plasma is electrically energized matter in a gaseous state, and is generated by passing gases through electric fields. Plasma particles consist of species that are extremely reactive, and therefore can attack or react with problematic chemical compounds on contact. These species are very strong oxidizers that can rapidly decompose other inorganic and organic compounds mainly in two ways: chemical (free radical-promoted) attack and direct electron impact.

In this project, we will develop an NTP treatment unit for air sanitization and odor control in poultry facilities. While the core technology is NTP, other techniques such as electrostatic precipitation will be employed to improve effectiveness and efficiency. The effect of the treatment on AI virus viability, decomposition of ammonia, H_2S, and removal of small particles will be evaluated. Furthermore, the economic, environmental, and health impacts will be analyzed.

Impacts: Minnesota is a leading poultry producer. It raised about 240 million turkeys in 2018 and the number of all layers on hand during January 2019 was 11.1million. The ***knowledge acquired and technology developed*** may be extended beyond poultry industry. With more than 24,000 registered feedlots in Minnesota, the proposed technology has a great potential to make a huge impact on controlling and reducing airborne pollutants in Minnesota livestock farms. By removing hazardous airborne biological and chemical contaminants, the health of humans, animals, and the environment will be protected.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Design, fabricate, and test an NTP treatment unit for destruction and removal of airborne contaminants in animal production facilities*

We will first use our current lab NTP treatment apparatus to develop and optimize the process. Additional NTP reactor configurations will be tested. An optimal configuration, a set of optimized processing parameters, and

scale-up parameters will be determined for the proposed prototype treatment unit for this study. Enhancement of airborne contaminant removal using electrostatic precipitation will be examined and the result will be used to determine if an electrostatic precipitation device will be implemented into the prototype unit. The destruction and removal of key airborne contaminants, i.e., selected pathogens (AI virus, *Salmonella*) and odorous compounds (ammonia, H_2S) will be evaluated when the unit is initially tested in labs.

ENRTF BUDGET: $285,000

Outcome	Completion Date
1. Key processing variables will be identified and quantified and basic biological and chemical contaminates removal mechanisms will be delineated	*06/30/2021*
2. Removal efficiency, air quality data, and energy efficiency will be evaluated	*12/31/2021*
3. An preliminary optimized system and process flow diagram will be delivered	*12/31/2022*

Activity 2: *Assess potential positive environmental, health, and economic impacts of the strategy*

After testing and study of the prototype unit in lab setting, the unit will be taken to a poultry barn in Rosemount Research and Outreach Center for field testing and demonstration. Data on destruction and removal of airborne contaminants, treatment capacity, energy consumption, and operation costs will be collected and analyzed. The environmental, health, and economic impacts of the strategy will be assessed under different scenarios. Stakeholders will be brought to the demo site to view the system and operation.

ENRTF BUDGET: $300,000

Outcome	Completion Date
1. Scale-up parameters will be determined for the optimized process flow	*03/31/2022*
2. Field test/demonstration system design will be completed	*06/30/2022*
3. Field test/demonstration system will be fabricated and tested in lab and on fields	*12/31/2022*
4. The field test/demonstration system will be demonstrated in WCROC *to the stakeholders*	*06/30/2023*

III. PROJECT PARTNERS:

A. Project team:

The project team consists of process and system engineers, veterinary medicine professionals, extension professionals: Roger Ruan (Bioproducts & biosystems Engineering or BBE, UMN), Yuying Liang (Veterinay Medicine, UMN), Paul Chen (BBE, UMN), Kevin Janni (BBE, Extension, UMN), and Sally Noll (Animal Science, Extension, UMN)

B. Partners NOT receiving ENRTF funding

Name	Title	Affiliation	Role
Peter Forsman	Owner	Forsman Farms	Help with field demonstration
John Snyder	President	Minnesga	Help with pilot system development

IV. LONG-TERM- IMPLEMENTATION AND FUNDING:

New scientific knowledge and experience on NTP based process for removal of airborne contaminants from poultry barns will be acquired through research, and the operation and demonstration on farm will raise significant interests from the stakeholders. We will seek industry partners and private, state, and federal funding to further develop and eventually commercialize the technology.

V. TIME LINE REQUIREMENTS:

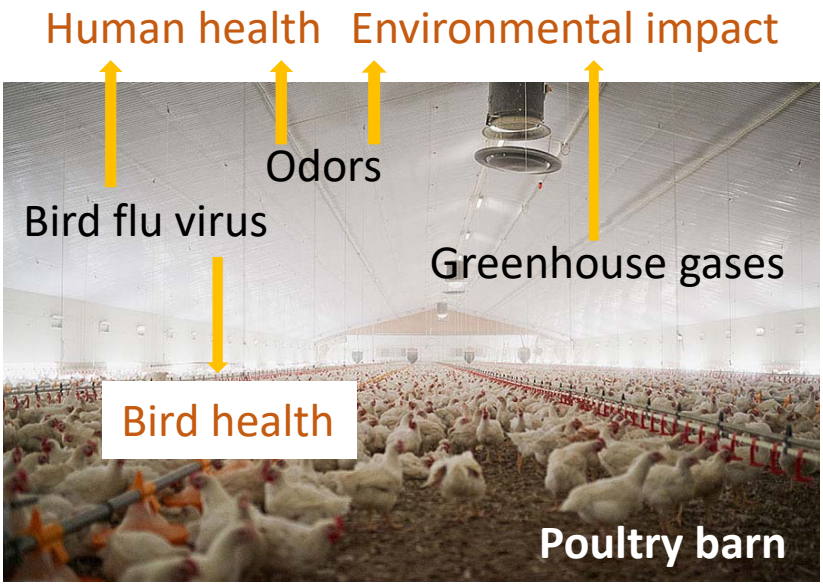
This project is planned for 3 years beginning July 1, 2020 and ending June 30, 2023. Most of the first 18 months will be focused on process improvement and parameter optimization, and full understanding of the proposed process, and much of the second 18 months will be focused on development, evaluation, and demonstration of the proposed demonstration system.

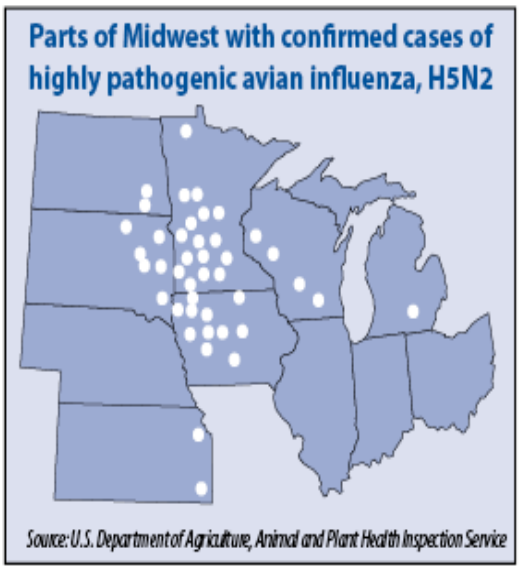
Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Roger Ruan
Project Title: Remove airborne contaminants from animal production facilities
Organization: University of Minnesota
Project Budget: $585,000
Project Length and Completion Date: 3 Years - June 30, 2023
Today's Date: 4/11/19

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 470,000	$ -	$ 470,000
Roger Ruan, PI/PD, 0.08 FTE, 3 years, $67,000, 73.5% salary, 26.5% fringe, - leading and managing lab and field testing project, leading demonstration, supervising post-doc associate			
Yuying Liang, co-PI, 0.04 FTE, $35,000, 73.5% salary, 26.5% fringe, coordinating lab testing and analysis, supervise post-doc			
Paul Chen, co-PI, 0.16 FTE, 3yrs,$64,000, project coordination, conducting R&D, project evaluation, progress report			
Kevin Janni, co-PI, 0.04 FTE, 3yrs, $35,000, 73.5% salary 26.5% fringe,, project coordination, coordinating field testing and demonstration			
Sally Noll, co-PI, 0.04 FTE, 3yrs, $35,000, 73.5% salary 26.5% fringe,, project coordination, coordinating field testing and demonstration			
Post-doc associates, 1.5 FTE, $234,000, 80.5% salary, 19.5% fringe, conducting R&D operations, demonstration, data acquisition and analysis			
Professional/Technical/Service Contracts			
	$ -	$ -	$ -
Equipment/Tools/Supplies			
Lab supplies, instruments, non-capital equipment for lab and field experiments and testing	$ 100,000	$ -	$ 100,000
Capital Expenditures Over $5,000			
	$ -	$ -	$ -
Fee Title Acquisition			
	$ -	$ -	$ -
Easement Acquisition			
	$ -	$ -	$ -
Professional Services for Acquisition			
	$ -	$ -	$ -
Printing			
	$ -	$ -	$ -
Travel expenses in Minnesota			
Travel to collect samples in fields and demonstrate site over the 3 year period	$ 5,000	$ -	$ 5,000
Other			
Sample analysis, equipment calibration, repair and maintenance	$ 10,000	$ -	$ 10,000
COLUMN TOTAL	$ 585,000	$ -	$ 585,000

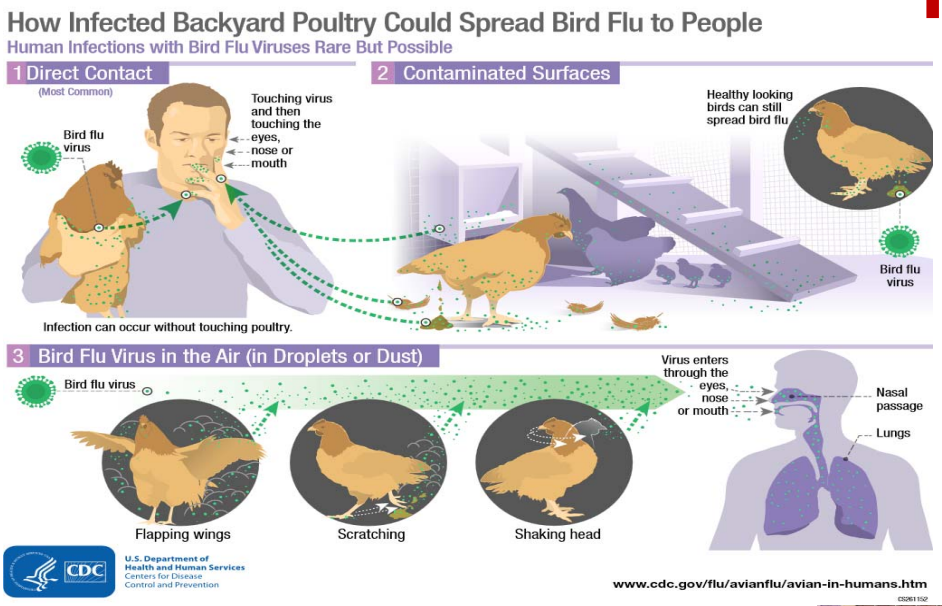
SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Unrecovered F&A	Secured	$ 315,000	$ -	$ 315,000

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
M.L. 2014, Chp. 226, Sec. 2, Subd. 08c	$ -	$ 1,000,000	$ 1,000,000	$ -





In 2015 a regional outbreak in Minnesota resulted in an estimated $647.2 million in economic damage and affected over 2,500 jobs.



Pathogens originated from animal facilities such as avian influenza virus Other airborne pathogens in poultry barns and hog farms, which have potential to harm humans

What can the gases (ammonia, hydrogen sulfide, methane, NOx, SOx) from animal manures do to human and the environment?

- Nuisance odors
- Contribute to the formation of secondary particulate matter (PM2.5) and tropospheric ozone, which are harmful to human health and the climate
- Harmful to animals too.

Dirty air
Pathogens
Gases

Sanitized air

Non-thermal plasma (NTP) reactor for AIV inactivation being developed at UMN

Project Manager Qualifications and Organization Description

Dr. Roger Ruan, Professor and Director, Center for Biorefining and Department of Bioproducts and Biosystems Engineering, University of Minnesota, Fellow of ASABE and Fellow of IFT, is the project manager of the proposed project. Dr. Ruan's research focuses on renewable energy and the environment as well as food safety and quality. Professor Ruan has published over 450 papers in refereed journals, has co-authored two books, and many book chapters, over 300 meeting papers and reports, and holds 17 US patents. He is also a top cited author in the area of agricultural and biological sciences. He has supervised over 65 graduate students, 110 post-doctors, research fellows, and other engineers and scientists, and 13 of his Ph.D. students and 8 other post-doctors hold university faculty positions. He has received over 170 projects totaling over $40 million in various funding for research, including major funding from USDA, DOE, DOT, DOD, LCCMR, and industries. He was the project manager of earlier LCCMR funded projects which resulted in issuance of a US patent and licensing of a technology.

Dr. Ruan has very active ongoing research programs in the areas of environmental and renewable energy engineering. They have more than twenty years of experience in development of non-thermal plasma (NTP) based processes for synthesis, decomposition, and disinfection applications. His research group has been developing processes for decomposition of odorous compounds, inactivation of avian influenza virus, wastewater treatment, waste utilization, etc. His team has experience in building bench and small pilot systems for testing and systems analysis. They are well published in these areas.

The Center for Biorefining is a University of Minnesota research center and help coordinate the University efforts and resources to conduct exploratory fundamental and applied research; provide education on bioenergy, biochemicals and biomaterials; stimulate collaboration among the University researchers, other public sector investigators, and private investigators involved in biobased production technology development; promote technology transfer to industries; and foster economic development in rural areas. The Center's research programs are founded by DOE, USDA, DOT, DOD, LCCMR, IREE, Xcel Energy, and other federal and state agencies, NGOs, and private companies. The Center is equipped with state of the arts analytical instruments, and processing facilities ranging from bench to pilot scale. In particular, they have the capability to develop various bioreactors for different purpose and the means to evaluate related processes.