Environment and Natural Resources Trust Fund
2010 Request for Proposals (RFP)

LCCMR ID: 229-G

Project Title:

Mercury Removal from Stack Emissions from Coal-Fired Power

LCCMR 2010 Funding Priority:

G. Creative Ideas

Total Project Budget: $ $1,770,621

Proposed Project Time Period for the Funding Requested: 2 years, 2010 - 2012

Other Non-State Funds: $ $0

Summary:

A pilot unit employing a novel catalyst will be installed for mercury removal from coal-fired power flue gas at an Xcel Energy host facility in Minnesota.

Name: David Mazyck

Sponsoring Organization: University of Florida

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Location:

Region: Metro

County Name: Sherburne

City / Township:

_____ Knowledge Base _____ Broad App. _____ Innovation

_____ Leverage _____ Outcomes

_____ Partnerships _____ Urgency _____ TOTAL

PROJECT TITLE: Mercury Removal via STC from Stack Emissions from Coal-fired Power

I. PROJECT STATEMENT

In Minnesota (MN), the harmful impacts of Hg on humans and the ecosystem have been recognized. Hg exposure, primarily from the consumption of fish caught in water bodies exposed to Hg pollution, can cause a superfluity of neurological dysfunctions and impairment. Most strikingly, research determined that children lost almost 1 intelligent quotient (IQ) point per 1 µg/L of Hg found in their mothers during gestation (Jorgensen 2004). To protect the health and wellbeing of the future population in MN, the Legislative Citizen Commission on MN Resources (LCCMR) Six-year Strategic Plan recommends significant reductions in mercury deposition (Goal D). The MN Pollution Control Agency (MPCA) has taken action in this arena and has developed a Hg reduction plan to be met in sequential phases by the years 2018 and 2025.

Burning coal for energy production is the largest contributor to anthropogenic Hg emissions in the state of MN (i.e., 1,716 lbs Hg emitted in 2005) (MPCA 2008). To meet the MPCA Hg emissions reduction projections for the coal-fired power industry, a robust technology that can be applied throughout the industry must be identified. Currently, the most widespread technique for removing Hg from the flue gas of a coal fired power plant is activated carbon injection (ACI). However, ACI has yet to be proven and when captured with the fly-ash, renders the saleable product un-useable due to the contamination with Hg. Therefore, the goal of this proposal is to manufacture, install, and test a Hg removal technology that outperforms AIC, in cost and performance, at a sub-bituminous coal-fired power plant.

The proposed technology utilizes a novel catalyst packing material, silica-titania composites (STC), which can capture greater than 95% of mercury in flue gas at far less operating costs than ACI (Table 1). Previous funding has supported the development and installation of a 1 MW pilot-scale system at a lignite coal-fired power plant in Texas. The pilot system is fully housed in a skid as shown in Fig. 1. The system has been operating since August 2008, and there have been no mechanical problems, no adverse impacts from fly ash, and acceptable pressure drop through the packed bed (i.e., 2.5" w.g.). The catalyst is anticipated to last 10 to 25 years before requiring replacement. Due to confidentiality, more details cannot be provided at this point, but both parties are pleased with the results.

This technology provides an innovative solution to Hg capture that will have transformational benefits to human health and the natural environment in MN. As an additional benefit, this technology will offer the coal-fired power industry a robust and economical technology that does not negatively impact the balance of plant issues, does not compromise the salability of fly ash, and is capable of adsorbing all species of Hg. When commercialized and implemented, this technology could be revolutionary to the electric utility industry on a national scale.

Table 1. Comparison of costs of Activated Carbon Injection (ACI) to STC Catalyst (STC) Costs per mega watt of power produced

	ACI/MW	**STC/MW**
Capital Cost	*$10,000*	*$29,000*
Operating Cost	*$26,000*	*$500*

II. DESCRIPTION OF PROJECT RESULTS

Result 1: *Design and Build* **Budget:** $ 900,784.65

The design and build process will begin with the fabrication of a 1 MW pilot unit using the specifications from the pilot unit installed at the lignite coal-fired power facility with modifications tailored for Xcel Energy's Sherco Facility in Becker, MN. The pilot-unit installation will include modification of existing infrastructure to accommodate a slip stream to the pilot unit.

Deliverable	Completion Date
1. Design and Fabrication of pilot unit	*3/1/2011*
2. Retrofit of existing structure for unit placement	*4/1/2011*
3. Unit installation	*5/1/2011*

Result 2: *Analysis* **Budget:** $ 869,836.66

Once the unit is installed, operation will commence. Hg will be monitored via carbon traps, and the Ontario Hydro Method in the influent and effluent of the unit to determine percent removal and oxidation of Hg. Other parameters such as temperature and pressure drop through the unit will also be monitored on the pilot skid and remotely. After testing this unit at Sherco, the unit will be moved to another host facility, Black Dog. Any necessary modifications will be made and the testing will be repeated to show the robustness of the technology. Throughout the duration of the project, continual communication and record keeping of every step of the project will be organized and documented. The project report will include a thorough presentation of Hg removal capabilities and trends, and an analysis of the expected costs of Hg capture using the STC technology in a commercial unit.

Deliverable	Completion Date
1. Performance data at Sherco	*10/1/2011*
2. Performance data at Black Dog	*5/1/2001*
3. Project Reporting	*7/1/2011*

III. PROJECT STRATEGY

A. Project Team/Partners

The key investigators on this project will be Dr. David Mazyck, Associate Professor at UF's Department of Environmental Engineering Sciences and Chief Technology Officer at Sol-gel Solutions, LLC (Sol-gel), and Dr. Anna Casasús, Research and Development Director at Sol-gel. UF is a leader in environmental engineering research and Dr. Mazyck has a strong research program in pollution control technology. Sol-gel was started in 2004 to facilitate commercialization of the STC technology developed at UF. Sol-gel exclusively licensed the technology from UF and has been working on its further development for a variety of applications, including those in the chlor-alkali and coal-fired power industries. The mission of Sol-gel is to help industries meet objectives related to product quality and environmental regulations through the proper selection of commercially-available technology or research and development of novel solutions. One such company, Xcel Energy Corporation, is motivated to find a solution for Hg removal and has agreed to provide a host facility for the proposed pilot unit, assistance with pilot study integration, and expertise related to the plant operations. A letter of support to this aspect is included.

B. Timeline Requirements

The total timeline required to achieve project results is 24 months as indicated by the completion dates above.

C. Long-Term Strategy

After successful completion of the pilot study proposed herein (Phase I), we would propose a Phase II study (100 MW study), proceeded by installation of full-scale unit(s).

Project Budget

IV. TOTAL PROJECT REQUEST BUDGET (*2* years)

BUDGET ITEM	AMOUNT
Personnel:	$ -
PI: Dr. Mazyck, FTE: 0.16, %sal: 77, %benefits: 23, duration: 2 years	49,593
Co-PI: Dr. Boyer, FTE: 0.08, %sal: 77, %benefits: 23, duration: 2 years	22,300
Project Manager: Riley, FTE: 0.16, %sal: 77, %benefits: 23, duration: 2 years	43,363
Administrative Coordinator: Strekalova, FTE: 0.21, %sal: 77, %benefits: 23, duration: 2 years	29,248
Post Doc: TBD, FTE: 1.0, %sal: 81, %benefits: 19, duration: 2 years	157,388
Graduate Students: TBD, FTE: 2.0, %sal: 93, %benefits: 7, duration: 2 years	109,104
Contracts:	0
Sol-Gel Solutions LLC. Pilot system fabrication, installation, and monitoring.	1,200,400
Equipment/Tools/Supplies:	0
Sorbent Trap Mercury Analyzer	30,000
Materials required for manufacturing extruded Silica-titania Composites to fill the proposed pilot-scale unit, and general lab consumables which include the following: 352 lb Degussa P25 TiO2, 2000 lb HS-40 Ludox colloidal silica, 700 lb Brightsorb D300 silica xerogel, 500 lb Deionized water, scale, Erlenmeyer flasks and graduated cylinders, disposable gloves, disposable lab wipes, containers for mixing, containers for holding and shipping finished materials, shipping costs	50,000
Travel:	0
Out-of-State: Travel between the University of Florida in Gainesville to Minneapolis, MN pilot study site at XCEL energy facilities.	40,000
Additional Budget Items:	
Tuition - Calculated on established monthly rates by the university as follows: Jul-Aug 2010: $675.72/month, Sep 2010 - Aug 2011: $777.07/month, Sep - Jun 2011: 893.64/month	39,225
	0
TOTAL PROJECT BUDGET REQUEST TO LCCMR	$ 1,770,621

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
In-kind Services During Project Period: *Indicate any in-kind services to be provided during the funding period. List type of service(s) and estimated value. In-kind services listed must be specific to the project.*	$ -	
Funding History: *Indicate funding secured prior to July 1, 2010 for activities directly relevant to this specific funding request. State specific*	$ -	

IV. REFERENCES

Jorgensen EB, Debes F, Weihe P, Grandjean P. 2004. Adverse Mercury Effects in 7 Year-Old Children as Expressed as Loss in "IQ." Odense:University of Southern Denmark. Available: <http://www.chef-project.dk/PDF/iq04louise5.pdf > [accessed 15 May 2004].

Minnesota Pollution Control Agency. Estimated Mercury Emissions in Minnesota for 2005 to 2018. Report No. wq-iw1-21 April 22, 2008.

Fig.1: Pilot unit skid for lignite coal-fired power application

DAVID W. MAZYCK, PH.D.

(a) Professional Preparation

- The Pennsylvania State University
  Civil Engineering B.S. (1995)
- The Pennsylvania State University Environmental Engineering M.S. (1996)
- The Pennsylvania State University Environmental Engineering Ph.D. (2000)
- US Army, Army Corps of Engineers Technical Drafting Specialist 1989-1991

(b) Appointments

Associate Chair for Research and Graduate Coordinator (January 2007-Present)
Associate Professor (August 2006-Present)
Assistant Professor (July 2000-August 2006)
University of Florida, Department of Environmental Engineering, Gainesville, Florida

- Leads a nationally and internationally recognized research program dedicated to advancing the current understanding of adsorption phenomena, photocatalysis, and air/water purification through novel engineered systems. Develops courses to educate engineers in the field of environment engineering, specifically water treatment design and adsorption phenomena.
- Technical Lead for Water Recovery (NASA Environmental Systems Commercial Space Technology Center) (2001-Present)

(c) Publications most closely related to project

- Stokke, J.M. and **Mazyck**, D.W. Development of a regenerable system employing silica-titania composites for the recovery of mercury from end-box exhaust at a chlor-alkali facility. *Journal of the Air & Waste Management Association* 58(4):530-537, 2008
- Stokke, J.M. and **Mazyck**, D.W. Photocatalytic degradation of methanol using silica-titania pellets: Effect of pore size on mass transfer and reaction kinetics. ES&T 42(10):3803-3813, 2008
- Pitoniak E, Wu CY, **Mazyck** DW, Powers KW, Sigmund W. Adsorption Enhancement Mechanisms of Silica-Titania Nanocomposites for Elemental Mercury Vapor Removal. *Environ. Sci. Technol.* 2005; 39(5): 1269-1274.
- Pitoniak E, Wu CY, Londeree D, **Mazyck** D, Bonzongo JD, Powers K, Sigmund W. Nanostructured Silica-Gel Doped with TiO2 for Hg Vapor Control**,** *Journal of Nanoparticle Research* 2003; 5: 282-292.

(d) Research Facilities

The University of Florida maintains one of the nation's leading sorbent research facilities under the direction of Dr. David W. Mazyck. Dr. Mazyck's research focuses on the purification of air and water via adsorption, photocatalysis, and/or a combination of the two for maintaining public health. Fundamentals of adsorption are used to tailor adsorbents through the optimization of physical (e.g., pore size distribution) and chemical (e.g., electron density) properties. More specifically, the surface chemistry of carbonaceous (e.g., activated carbon) and silica adsorbents are studied to better understand the adsorbent-adsorbate interface. The robustness of these adsorbents is enhanced through the incorporation of photocatalysts (e.g., TiO_2) to either improve remediation efficiency/capture or to accomplish in-situ regeneration. In seven years, Dr. Mazyck has secured more than $4.0 M is extramural grants and contracts including funding from DOE, NSF, EPA, NSF, and NASA. Since joining the University of Florida in 2000, Dr. Mazyck has published over 34 journal articles, has been presenter or co-author in over 46 oral presentations and 16 posters in national and international conferences, has one patent issued and five pending, and has graduated or is advising 9 Ph.D. candidates, 20 M.S. students, and more than 40 undergraduates.

(e) Responsibilities

Dr. Mazyck will oversee all research activities to ensure that tasks are completed by the proposed deadlines with the proper quality control. All acquired data will be compiled, analyzed, and condensed by the team at UF and Sol-gel into a series of charts and graphs that summarize the various test procedures, results and conclusions for integration into various required reports.