State of California
AIR RESOURCES BOARD

Resolution 09-24

February 26, 2009

Agenda Item No.: 09-2-7

WHEREAS, the Air Resources Board has been directed to carry out an effective research program in conjunction with its efforts to combat air pollution, pursuant to Health and Safety Code Sections 39700 through 39705;

WHEREAS, a proposal entitled "Removal of H_2S from Biogas and NO_x from Engine Exhaust at a Dairy Digester Using Microwave Technology" has been submitted by Sacramento Municipal Utility District in response to the 2008 Innovative Clean Air Technologies (ICAT) Program solicitation;

WHEREAS, the proposal has been independently reviewed for technical and business merit by highly qualified individuals; and

WHEREAS, the Research Division and Stationary Source Division staff and the Executive Officer and Deputy Executive Officers have reviewed and recommend for funding:

> Proposal entitled "Removal of H_2S from Biogas and NO_x from Engine Exhaust at a Dairy Digester Using Microwave Technology", submitted by Sacramento Municipal Utility District, for a total amount not to exceed $246,309.

NOW, THEREFORE BE IT RESOLVED that the Air Resources Board, pursuant to the authority granted by Health and Safety Code Section 39703, hereby approves the following:

> Proposal entitled "Removal of H_2S from Biogas and NO_x from Engine Exhaust at a Dairy Digester Using Microwave Technology", submitted by Sacramento Municipal Utility District, for a total amount not to exceed $246,309.

BE IT FURTHER RESOLVED that the Executive Officer is hereby authorized to initiate administrative procedures and execute all necessary documents and agreements for the efforts proposed herein, and as described in Attachment A, in an amount not to exceed $246,309.

I hereby certify that the above is a true and correct copy of Resolution 09-24, as adopted by the Air Resources Board.

Monica Vejar

Monica Vejar, Clerk of the Board

ATTACHMENT A

Innovative Clean Air Technologies (ICAT) Grant Proposal:

"Removal of H_2S from Biogas and NO_x from Engine Exhaust at a Dairy Digester Using Microwave Technology"

Background

Statewide, there are over 2,100 dairies in California with a potential to produce about 40 million cubic feet per day of biogas with electrical generation capacity of about 136-140 MW. Sulfur in the biogas precludes all commercially available post combustion controls using catalysts without reliable and robust H_2S removal. Assuming such a treatment technology is available and is used to enable power production from biogas, this represents a potential greenhouse gas reduction of about 20 million cubic feet per day of methane from dairies. The undeveloped electricity generation potential from California landfills, wastewater digesters and food digesters combined is estimated at an additional 600 MW which represents another 85 million cubic feet of methane.

Objective

The purpose of the demonstration is to show the use of an integrated H_2S and NO_x removal system that will significantly reduce NO_x and SO_x emissions from biogas engines to meet the CARB 2007 emission standards.

Methods

A pilot plant for H_2S removal will be modified and installed at an existing dairy farm with a manure digester. A NO_x removal system using alternating carbon adsorbers and microwave powered regeneration will be fabricated and installed. A microwave NO_x reactor will be used to destroy the NO_x. The system will be bench tested, shipped to the dairy site and installed on the exhaust of a 212 kW engine. After a 1 month start up period, the system will be demonstrated for an additional 5 months of continuous operation. The equipment will be removed from the dairy after the demonstration.

Expected Results

It is expected that the objective of the project will be met, and the effectiveness of the technology in allowing the use of digester biogas for power generation, compliant with current emission standards, will be demonstrated.

Significance to the Board

The 2007 CARB emission standards for biogas engines are the most stringent in the US. At the time of submission of this proposal, there are no certified engines and there are at least 5 dairy digester systems with applications pending for permits with local air quality management districts to operate engines on biogas. At this time, there are no

engines manufacturers or post combustion emission control providers that will provide guarantees for emission controls that meet CARB 2007 standards for NO_x. Some dairies have postponed construction of digesters until a biogas engine is successfully permitted in the central valley using proven technology. This technology may be used to retrofit existing anaerobic digester engines to meet current and future emissions standards.

Sulfur in the biogas precludes all commercially available post combustion controls using catalysts without reliable and robust H_2S removal. The integrated pollution capture and microwave system described here will provide a new emission-prevention technology to significantly reduce NO_x and SO_x emissions from biogas engines to meet the CARB 2007 emission standards, allowing for significant methane reductions.

In addition to biogas sources (*e.g.*, dairy digesters, landfill capture systems, municipal waste digesters), this technology could also potentially be applied to natural gas engines, CHP systems and temporary use of back-up generators in California. Additionally, the sulfur pretreatment technology could be used to treat biogas prior to pipeline injection and prior to use in fuel cells for power generation.

Applicant: Sacramento Municipal Utility District

Project Period: April, 2009 to April, 2010

Principal Investigator: Mark Rawson

ICAT Funding: $246,309

Co-funding: $348,958

Past Experience with This Principal Investigator: None.

ICAT Funding Prior to 2008

Year	2007	2006	2005
Funding	$0	$0	$0

BUDGET SUMMARY

Sacramento Municipal Utility District

"Removal of H2S from Biogas and NOx from Engine Exhaust at a Dairy Digester Using Microwave Technology"

Direct Costs and Benefits	**ICAT**	**Total**
1. Labor	$ 0	$ 51,562
2. Employee Fringe Benefits	$ 0	$ 24,874
3. Subcontractors	$ 246,309	$ 451,567
4. Equipment	$ 0	$ 0
5. Travel and Subsistence	$ 0	$ 0
6. Materials and Supplies	$ 0	$ 0
7. Other Direct Costs	$ 0	$ 0
Total	$ 246,309	$ 528,003
Indirect Costs		
1. Overhead	$ 0	$ 67,264
2. Other Indirect Costs	$ 0	$ 0
Total	$ 0	$ 67,264
Total Project Costs	**$ 246,309**	**$ 595,267**

Subcontractor AFT

Direct Costs and Benefits	**ICAT**	**Total**
1. Labor	$ 24,600	$ 24,600
2. Employee Fringe Benefits	$ 8,610	$ 8,610
3. Subcontractors	$ 0	$ 0
4. Equipment	$ 0	$ 0
5. Travel and Subsistence	$ 9,583	$ 9,583
6. Materials and Supplies	$ 39,000	$ 39,000
7. Other Direct Costs	$ 13,000	$ 13,000
Total	$ 94,793	$ 94,793
Indirect Costs		
1. Overhead	$ 0	$ 28,290
2. Other Indirect Costs	$ 0	$ 0
Total	$ 0	$ 28,290
Total Project Costs	**$ 94,793**	**$ 123,083**

Subcontractor CHA

Direct Costs and Benefits		**ICAT**		**Total**
1. Labor	$	53,560	$	53,560
2. Employee Fringe Benefits	$	18,746	$	18,746
3. Subcontractors	$	0	$	0
4. Equipment	$	0	$	78,400
5. Travel and Subsistence	$	21,610	$	21,610
6. Materials and Supplies	$	54,600	$	54,600
7. Other Direct Costs	$	3,000	$	3,000
Total	$	151,516	$	229,916
Indirect Costs				
1. Overhead	$	0	$	61,594
2. Other Indirect Costs	$	0	$	0
Total	$	0	$	61,594
Total Project Costs	**$**	**151,516**	**$**	**291,510**