

PROPOSAL FORM

PITA ♦ FISCAL YEAR 2008

Institute for Complex Engineered Systems (ICES)
Carnegie Mellon University

Proposal Number: CMU ##
Awarded Amount: \$

(For administrative purposes only)

INSTRUCTIONS: Please use this form to submit your PITA proposal. Fill-in complete answers for all questions. Submit complete proposals along with your completed PITA budget form (see below) no later than September 28, 2007. **BUDGET INFORMATION:** A specific budget template has been created for PITA proposal submission. This template will automatically calculate the correct rates negotiated for the PITA program and provides fields for you to include salaries, equipment, consultants, travel (within PA only), supplies, industry cost share, and leverage funds. An electronic copy of the budget template is available on the Call for Proposals page on the PITA web site at www.ices.cmu.edu/pita or by request from Matthew Sanfilippo (mattsanf@cmu.edu).

1. Project Title: Biodiesel Fuel Effectiveness in a Power/Cooling/Heating/Ventilation System for a Building

- A. Is this proposal a renewal or continuation of a previous PITA project? (check one) yes no
If yes, please provide the account string & title of that project:

BioDiesel Fuel Effectiveness in a Power/Cooling/Heating/Ventilation System for a Building: 16571.1.59.1040844
\$53,368 made available 13 June 2007 to 31 May 2008

- B. If your project is funded, would you be interested in participating in the SURE Thing program? (ie. Accepting a qualified, non-CMU, PA college student to work as a research assistant on this project during the summer of 2008.) (check one) yes no

2. Research Team:

- Principal Investigator - David Archer, Mechanical Engineering/Architecture, archerdh@andrew.cmu.edu
- Co-Principal Investigator - John Wiss, Mechanical Engineering, johnwiss@andrew.cmu.edu
- Graduate Student - Fred Betz, Architecture fbetz@andrew.cmu.edu
- Undergraduate Student(s) - (department information and names, if known):

3. Other Project Participants:

- CMU - Department of Mechanical Engineering: Prof Allen Robinson, Marissa Miracolo (separately supported by a PITA grant at CMU)
- Center for Advanced Fuel Technology: Marc Portnoff
- Industry - CTI Biofuels: Kevin Reilly
- Astorino Engineers; Patrick Branch, Arthur Bell
- Logical Automation: Kirk Hamilton, James Ostronic
- Lehigh University - Department of Mechanical Engineering: Prof S Neti, Tim Guider (separately supported by a PITA grant at Lehigh)
- Milwaukee School of Engineering - Christopher Damm, Brian Goodwin (supported by DOE/EERE/NETL)

4. Contact Information for Non-CMU Project Participants:

- Kevin Reilly: President, 412 841-8884, reilly@ctibiofuels.com
- Patrick Branch: Principal, 412 209-2854, PIBranch@astorino.com
- Kirk Hamilton: President, 412 444-0444, KHamilton@logicalautomation.com
- Sudhakar Neti: Professor, 610 758-4117, sn01@lehigh.edu
- Christopher Damm: Professor, 414 277-7543, damm@msoe.edu
- Brian Goodwin: Student, 815-222-6078, goodwinb@msoe.edu

5. Executive Summary of Project:

CMU's School of Architecture, in cooperation with its Department of Mechanical Engineering, has now completed the installation of a bioDiesel fueled engine generator with heat recovery equipment to provide power, cooling, heating, and ventilation for the Intelligent Workplace, the IW. The architectural features and energy supply provisions of the IW will demonstrate that the

energy requirements for operating a building can be reduced by a factor of 8 or more and can be met by solar and renewable energy. This demonstration is significant since the operation of buildings now requires 40% of the primary energy consumed in the U.S.

The project will test and evaluate the performance of the bioDiesel fueled energy supply in generating power, in delivering heat as steam and heated water, in delivering chilled water, and in reducing emissions of gaseous and particulate pollutants over a wide range of bioDiesel fuels and fuel flows. The project will also develop algorithms for operations that will enable the bioDiesel fueled system, together with campus grids, to provide for the energy needs of the IW efficiently and economically.

Performance models based on fundamental scientific and engineering principles, now being programmed, will be completed for both the bioDiesel fueled engine itself and for the integrated engine, generator, heat recovery equipment, the IW, and the campus grid power, steam, and chilled water supply systems. These models will be used to analyze data and to project annual energy production and operating costs. They will also be useful in developing and evaluating systems designs for a wide variety of buildings.

Three Pennsylvania companies have been involved in the detailed design and installation of this bioDiesel fueled energy supply based on the preliminary engineering carried out by CMU students and faculty: Astorino Engineers, Logical Automation, and Wayne-Crouse. CTI Biofuels will provide fuels for the project. All of these companies foresee significant benefits both to their business and to the U.S. as a whole from successful pursuit of this project proposed to PITA.

6. Description of the Project

The Intelligent Workplace, the IW, is a 6000 ft² space built on the roof of MMCH to provide offices, meeting rooms, and work areas for students and faculty the School of Architecture's Center for Building Performance and Diagnostics. It has special architectural features to promote the health, productivity, and comfort of its occupants and to reduce the energy required for its operation – power, cooling, heating, and ventilation. Energy requirements are less than one quarter those for conventional building space.

An advanced energy supply system, an ESS, has been designed for the IW that will meet its energy requirements from solar heat and renewable fuel with a further energy reduction of two over conventional means of energy supply for building spaces. This ESS is now being assembled. It comprises:

- parabolic trough solar thermal receivers providing heated and, through an absorption chiller, chilled water for heating and cooling units in the IW.
- a bioDiesel fueled engine generator with heat recovery exchangers producing power, steam from the engine exhaust for a second absorption chiller, and heated water from the engine coolant.
- a ventilation unit incorporating enthalpy recovery, desiccant dehumidification, and temperature conditioning of the outdoor air supply by an air based heat pump.

The U. S. DOE, the Pennsylvania DEP, and industrial firms have supported the acquisition and installation of equipment for IW's ESS. The installation has involved detailed engineering from Astorino Engineers and Architects based on the preliminary design of Carnegie Mellon. Logical Automation has provided planning, hardware, and software for data acquisition and system control. Wayne-Crouse has carried out the installation of the bioDiesel fueled building energy supply system. The cost of design, procurement, and installation of this system has exceeded \$700 k. But now additional funds are needed to conduct experiments on the bioDiesel engine generator and to evaluate its performance in providing power and heat in various forms for IW operation from bioDiesel fuels that will be provided and characterized by CTI Biofuels.

CTI Biofuels is a firm that is commercializing technology developed by Carnegie Mellon's Center for Advanced Fuel Technology. They are designing, manufacturing, operating, and selling plants for the production of 5-10 million gallons/year of biodiesel fuel from a wide variety of sources: soy, rape seed, and palm oils; animal fats; and yellow grease. They will construct and operate one of these plants on Neville Island on the site of a former rendering plant.

Two hundred fifty gallon test samples will be produced in the CTI Biofuels pilot production facility on Pittsburgh's South Side, characterized in their Laboratories and delivered to the IW for test in the engine. The tests on the biodiesel engine generator and heat recovery equipment now installed and being commissioned in MMCH C9 will determine

- the effect of the fuel on the engine capacity, limited by smoke or emissions or by the maximum volumetric flow of the fuel.
- the efficiency of the engine and its heat recovery equipment producing power, steam, and heated water at design and at three part load conditions.
- the gaseous emissions from the engine: NO, NO₂, CO, CO₂, and unburned hydrocarbons.
- the particulate emissions – smoke, carbon, and hydrocarbon based. Detailed particulate characterization; size, composition, and concentration; will be measured and studied in a companion project currently receiving PITA support.
- pressure-time traces in the engine cylinders. These traces will be obtained and used to analyze vaporization and combustion of the fuel and to optimize fuel injection timing for power production and emissions reduction.
- the performance of the engine turbocharger in increasing the capacity and efficiency and of the steam generator/muffler in recovering heat from the engine exhaust will be analyzed in a companion PITA project at Lehigh University.

The tests will be carried out cooperatively by three graduate students. One will be primarily concerned with the data on engine performance; the other two, supported by the companion PITA projects, with the data on the turbocharger and steam generator and with data on emissions, particularly particulates. The analysis of particulate emissions will be carried out in the laboratory of the Center for Atmospheric Particulate Studies, CAPS.

Performance models based on fundamental scientific and engineering principles will be completed both for the Diesel engine and for the overall bioDiesel fueled energy supply system comprising the engine, the generator, the heat recovery equipment, the IW with its energy demands, and the campus power, steam, and chilled water grids. The models will be used

- to check, analyze, and incorporate the experimental data from the engine and from the heat recovery equipment: the steam generator, the fan cooled radiator, the water heater, and the steam driven absorption chiller.
- to estimate the annual performance of the bioDiesel energy system, its efficiency and operating cost, in providing for the IW's energy needs. The annual cost of IW energy supply based on biodiesel fuel will be compared to that based on purchased power and natural gas. The environmental costs/benefits of biodiesel fuel use will also be assessed.
- to develop, test, and evaluate various control algorithms devised for operating the supply system with the IW and to assist the development of improved controls, a significant technical challenge.
- to extend the capability for the design and evaluation of the performance of a this distributed generation; combined cooling, heating, power, CHP, energy supply system for a wide range of fuels and building applications.

7. Anticipated Results of the Project:

The tests of bioDiesel fuel use in the engine generator with the associated heat transfer equipment will clearly delineate the capabilities of the system to produce power and heat as steam and heated water for use in the IW. The engine and energy supply system performance models, calibrated with operating data, will be validated and will prove effective tools in assessing operational algorithms and in calculating the efficiency, cost, and environmental impact of the annual operation of the system in providing power, cooling, and heating to the IW. These models will also prove useful in the design and evaluation of energy supply systems for a wide variety of building applications.

The work is expected to show that

- 100% bioDiesel fuel can be used in a conventional Diesel engine with no operational problems.
- 70% efficiency in the use of bioDiesel fuel can be achieved by this building energy supply system.

- emissions of gaseous and particulate pollutants can be lower than those for a conventional power plant and coupled with heat production from natural gas.
- the engine and energy supply system models can be effectively used in the development, design, operation, and evaluation of systems for a variety of building applications.

Reports and publications will be produced by this project proposed to PITA. The test data and its evaluation will show that this facility is unique, and effective. Further funding should be available from the U. S. DOE and various other organizations interested in reducing the consumption of energy in buildings and in the use of renewable fuels. .

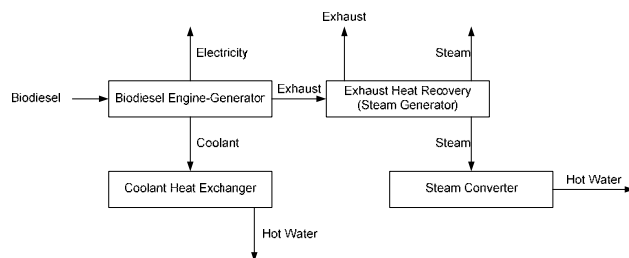
8. Relationship to PITA Goals and Potential Impacts on PA

This project supports PITA strategic goals:

- It has had and now has the active participation of three Pennsylvania companies: Astorino Engineers, Logical Automation, and CTI Biofuels. CTI is a corporation located in Pittsburgh, PA, that is constructing, operating, and selling plants for the production of biodiesel fuel from renewable energy sources.
- It involves graduate students and faculty of Carnegie Mellon working closely with the executive and the technical personnel of these companies.
- It promotes interchange of technical knowledge concerning biofuels and their use in engines for building energy supply among all the participants in the project.
- It provides business opportunities for Astorino Engineers and Logical Automation, both Pittsburgh based firms based on their experience in the detailed design and installation of this integrated building energy supply system using a renewable fuel.
- It opens a new market areas for CTI Biofuels in the sale of bioDiesel fuel and of biofuel production plants supplying fuel for systems providing power, cooling, heating, and ventilation for buildings.
- It provides a unique facility for research and development and for teaching at Carnegie Mellon. In the future it promises to attract both funding and students
- It deals directly with the challenge of Pennsylvania Governor Edward G. Rendell in his talk at Carnegie Mellon promoting the production and use of biodiesel fuels in this state and his Energy Independence Strategy.

9. Past Results Enabled by PITA Funding

To date PITA funds have been used in overseeing the installation and in planning for the commissioning and operation of the bioDiesel fueled energy supply system. PITA funds, \$53 k, were made available 13 June 2007. The installation of the system was completed and commissioning initiated on 4 September 2007. Funds presently on hand, 31 August 2007, are \$45.9k. It is expected that no unexpended funds will remain on 31 May 2008. Additional PITA 2008 funding will urgently be needed to carry out the proposed testing program.



BioDiesel Fueled Energy Supply System for the IW



BioDiesel Engine Generator with Heat Recovery Equipment in MMCH C9

CARNEGIE MELLON UNIVERSITY SUBMISSION
Institute for Complex Engineered Systems (ICES)
PITA (FY 07-08) BUDGET

Please fill in the blue cells only. Benefits, F&A, leverage, GTR tuition cost-sharing, and totals will be automatically calculated.

This color block =	Manual Enter
This color block =	Automatic Calculation

Oracle String Administrative Use Only

Principal Investigator Name David Archer

PI Phone Extension 8 2004

PI Department Mechanical Engineering, Archit

Submission Date 9/28/2007

FT PERSONNEL (Last, First)	HOME DEPT	% Effort	AY/CY/SU	Amount
1				\$ -
2				\$ -
3				\$ -
<i>Subtotal</i>				\$ -

GRAD STUDENT NAME	HOME DEPT	% EFFORT		FY06/07 PITA	Amount
1 Frederik Betz	Architecture	100%	PITA TUITION	\$ 23,120	\$ 23,120
		100%	DEPT. GTR TUITION SHARING	\$ 10,880	\$ 10,880
		100%	ICES 12 MONTH STIPEND	\$ 23,485	\$ 23,485
2		0%	PITA TUITION	\$ 23,120	\$ -
		0%	DEPT. GTR TUITION SHARING	\$ 10,880	\$ -
		0%	ICES 12 MONTH STIPEND	\$ 23,485	\$ -
<i>Subtotal for PITA stipend/tuition only</i>					46,605.00

UNDERGRADUATES	Name if Known	Amount
	Undergraduate 1	\$ -
	Undergraduate 2	\$ -
<i>Subtotal</i>		\$ -

BENEFITS	Amount
Benefits at 27.2%	\$ -
<i>Subtotal</i>	\$ -

OPERATING	EXPENDITURE TYPE	Amount
	Books/Periodicals	\$ -
	Consulting	\$ -
	Copying	\$ -
	Data Processing	\$ -
	IC Computing Facilities	\$ -
	IC Postage	\$ -
	LD Telephone	\$ -
	Maintenance	\$ -
	NC Equipment	\$ -
	NC Software	\$ -
	Technical Supplies	\$ -
	Publishing	\$ -
	Other - please explain below	\$ -
<i>Subtotal</i>		\$ -

TRAVEL - MUST BE WITHIN PENNSYLVANIA	Amount	
Destination/Purpose		
1	\$ -	
2	\$ -	
<i>Subtotal</i>		\$ -

CAPITAL EQUIPMENT/SOFTWARE	Price	Qty	Amount
Description			
1			\$ -
2	9/27/2007		\$ -
<i>Subtotal</i>			\$ -

SUBCONTRACT (please attach subrecipient budget, SOW and contact information)		Amount
Subrecipient name		
		\$ -
	<i>Subtotal</i>	\$ -
OTHER (Please justify)		Amount
		\$ -
		\$ -
	<i>Subtotal</i>	\$ -
SUBTOTAL		46,605.00
INDIRECT = Subtotal of all direct costs* 11.11.%		5,177.82
TOTAL REQUESTED PITA AMOUNT		51,783
TOTAL GTR SHARED BY GRADUATE STUDENT'S HOME DEPARTMENT(S)**		10,880

**If students are budgeted from multiple departments, shared GTR will be allocated to each student's home department.

*****Please note that all sources of leverage (cost-sharing, matching, etc.) SHOULD NOT be included in the above budget, but listed below.**

OTHER JUSTIFICATION

Over \$428 k in funds from the U. S. DOE/EERE/NETL (and \$287 k from the Pennsylvania DEP) have been provided to design, procure, and construct this building energy supply facility for research and development in the utilization of bioDiesel fuels and in the design and control of such systems. PITA funds are now urgently needed to operate this facility and to initiate and conduct the planned research and development program.

LEVERAGE

Amount Requested	\$ 51,783
Leverage Requirement	\$ 103,566

SOURCES OF LEVERAGE

SOURCE (Company, Agency, etc.)	CATEGORY TYPE (Please see below chart or RFP)	AMOUNT	ORACLE STRING (if known)
1 CTI Biofuels	A	\$4,000	Contributed fuel, analyses
2 U. S. DOE/EERE	C	\$428,000	16096.1.3.1070068
3			

The guideline is \$2 of expended leverage for each \$1 of expended PITA funds. The leveraged funds identified in a project proposal must be in place before PITA funds are released to the project and must be expended during the duration of the PITA project.

Check here if leverage pending

Leveraged Funds. Leveraged funds fall into four broad categories (in general order of importance):
A. New Cost Matching from Pennsylvania
B. Existing cost matching from Pennsylvania industrial partners related to the proposed project goals
C. New cost matching from non-Pennsylvania sources (e.g. federal government, out-of-state industrial partners)
D. Existing funds related to the proposed project goals that do not fall into the categories above and that are not from Pennsylvania State government sources.

Please call Rhonda Moyerat 268-6410 or send email to rm7q@andrew.cmu.edu with any questions.



21 September 2007

Dr David Archer
Carnegie Mellon University
5000 Forbes Avenue, MMCH 415
Pittsburgh, PA 15213-3890

Dear David,

As you are aware, CTI Biofuels is a Pennsylvania company that is commercializing a process to produce biofuels from a wide variety of feedstocks – soy, canola, vegetable oils, and animal fats. This process was developed by Carnegie Mellon’s Center for Advanced Fuel Technology. CTI manufactures and sells the equipment for complete biofuel production plants with capacities of 5 to 10 million gallons/year.

You are applying for a PITA grant to operate a biodiesel engine generator with heat recovery equipment that will now provide power, cooling, and heating for Carnegie Mellon’s Intelligent Workplace. CTI will provide the fuels for test in this system. We will supply and deliver 250 gallon batches of biodiesel fuel from each of four different sources from our first production plant, now operating in Iowa. We will provide the technical data for the use of each batch. And we will provide consultation on the handling, storage, and use of these fuels. An estimated value of these fuels, delivered, is approximately \$4000; our advice is, of course, invaluable.

The results of your testing engine performance and emissions associated with our biodiesel fuel will be of significant value to us in selling both our production plants and the fuel that they produce. Your work will also develop a new market for biofuels, building energy supply. CTI is pleased to work with you. We are hopeful that PITA will continue to support the operation of your system as they supported its installation in the past months.

Sincerely,

A handwritten signature in black ink that reads "Kevin P. Reilly".

Kevin P Reilly
CEO

ARCHITECTURE
ENGINEERING
INTERIOR DESIGN
DESIGN/BUILD

ASTORINO

September 24, 2007

Dr. David Archer
Center for Building Performance and Diagnostics
5000 Forbes Avenue, MMCH 415
Pittsburgh, PA 15213-3890

Dear Dr Archer:

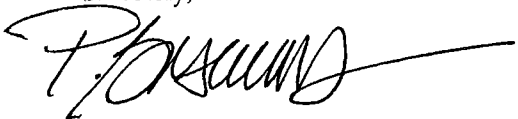
You are applying to the Pennsylvania Infrastructure Technology Alliance, PITA, at Carnegie Mellon University for a grant providing funds to test, operate, and evaluate the 25 kW bioDiesel fueled engine generator with heat recovery equipment. This system will provide power, cooling and heating for the Intelligent Workplace. It will demonstrate that over twice as much energy can be obtained from a renewable fuel, used in such a system for a building, than in an engine for a vehicle.

You have asked us to state for inclusion in your PITA proposal how Astorino has and will participate in this project and what benefit we expect to gain as a Pennsylvania company from this participation. Astorino prepared the detailed drawings for the installation of this system, based on your preliminary plans and specifications, with funding provided by the U. S. DOE/EERE. Previously, we also similarly prepared detailed plans for the installation of your steam driven absorption chiller and its auxiliaries that provide the cooling function in the overall bioDiesel fueled building energy supply system. Astorino performed this work gratis: an estimated contribution to the project of over \$38 k.

Astorino believes that both Carnegie Mellon and we have benefited from this cooperative effort. In particular, we have benefited from an understanding of and involvement with the details of this advanced building energy supply system. This knowledge is helpful in preparing proposals to our clients interested in efficient building operation and in preparing drawings for the resulting work.

Astorino looks forward to continuing cooperation with Carnegie Mellon dealing with the testing, operation, and evaluation of the bioDiesel engine with heat recovery system for which we provided the detailed plans and which has proved a useful reference in our business.

Sincerely,



Patrick I. Branch, PE
Chief Operating Officer

227 Fort Pitt Boulevard
Pittsburgh Pennsylvania 15222
T E L 412 765 1700 F A X 412 765 1711
W W W astorino.com

LOGICAL AUTOMATION

Providing Complete Building Control Solutions

AUTOMATED LOGIC
CORPORATION
HVAC DDC Control Products

Phoenix Controls
Corporation
Precision Airflow Control Products

September 24, 2007

Dr. David Archer
Carnegie Mellon University
5000 Forbes Avenue, MMCH 415
Pittsburgh, PA 15213-3890

Dear Dr. Archer,

Logical Automation, Inc. is a Pennsylvania corporation that provides equipment and services for instrumentation and control along with data acquisition, display, and analysis related to a wide range of operations in buildings. For example, as you well know, Logical Automation has worked with Carnegie Mellon in its projects dealing with the bioDiesel fueled engine generator and its heat recovery equipment and also with its solar thermal heat supply. Both of these systems are integrated with the Intelligent Workplace to provide energy as power, cooling, heating, and ventilation. Our work on these projects was funded by both the U. S. DOE/EERE and the Commonwealth of Pennsylvania's DEP.

We believe that not only has Carnegie Mellon benefited from our services, but also we have significantly benefited in this work through direct involvement and experience with the design and installation of instrumentation and controls for systems involving new, effective, efficient technologies for energy supply in buildings. We believe that this experience will provide our company with significantly increased capability in responding to clients interested in energy conservation.

We understand that you are now applying for a PITA grant to test and operate the bioDiesel engine generator with its heat recovery equipment. Certainly, we will support you by insuring that our instrumentation and control system operates effectively, as it was designed. And Logical Automation looks forward to this operation of the system with the funds provided by the PITA grant that you now seek.

Sincerely,



Kirk D. Hamilton
President & CEO