U.S. EPA NCER STAR Proposal Abstract

1. Research Category and Funding Opportunity Number: P3 Award: A National Student Design Competition for Sustainability Focusing on People, Prosperity, and the Planet, EPA-G2006-P3-Z5

2. Title: Solar Pasteurizer with Integral Heat Exchanger for Treating Water in Rural Areas

3. Faculty Advisors: Advisor: Robert Stevens, Mechanical Engineering, rjseme@rit.edu
Co-advisors: Margaret Bailey, Mechanical Engineering, mbbeme@rit.edu
Andres Carrano, Industrial and Systems Eng. alceie@rit.edu
Brian Thorn, Industrial and Systems Eng. bkteie@rit.edu

4. Institutions: Rochester Institute of Technology, Rochester, NY

5. Student Represented Departments: Mechanical, Industrial, and Electrical Engineering

6. Project Period: September 15, 2006 through May 30, 2007

7. Project Amount (EPA): $10,000

8. Total Project Amount: $10,000

9. Project Summary: According to the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation there are currently 1.1 billion people without access to safe water on the planet. Every year more than five million people die from the lack of safe water and improper sanitation. Children are the primary victims, therefore cutting short their opportunity to grow-up and be productive and contributing citizens in their communities. Although there has been significant progress over the past decades to improve access to safe water in urban areas, many existing water treatment technologies are not suitable for rural applications where populations are more dispersed and electrical power supply is unpredictable or nonexistent. A range of alternative water technologies are required to fully address the needs of rural areas. The objective of this project is for a multidisciplinary capstone team to design, build, and test a novel solar pasteurizer as part of RIT's Multidisciplinary Design Experience. Solar pasteurization, as a means of treating water in remote rural areas without electrical power, is based on the principle of using solar energy to thermally kill pathogenic protozoan, bacteria and viruses at temperatures below the boiling point. Solar pasteurization is potentially well suited for home, school, and small health clinic applications. Pasteurization has the unique advantage over other water treatment technologies in that it does not require scarce fuel wood, a source of chlorine, high maintenance, or specialized imported system components. Early solar pasteurization technologies were based on batch systems that had marginal throughput. Higher production rates can be obtained by allowing continual flow through the system using simple flow control devices and recovering the heat from the treated water. Large flow through systems with separate off the shelf solar collection and heat exchanger components have been developed, but are expensive. The novel approach taken in this project is to integrate the solar collection and heat exchanger into a single unit using materials and fabrication techniques readily available in the developing world. This approach has the potential to create a cottage industry producing water treatment technologies which will improve the health of rural populations. The multidisciplinary design team will 1) review the available pasteurizer literature, 2) define appropriate design specifications, 3) review the constraints imposed by resource availability in developing countries, 3) develop a series of integrated solar pasteurizer concepts, 4) select a design concept to develop further based on appropriate criteria (effectiveness, costs, manufacturability, etc), 5) present the design to a technical review panel and partners in Venezuela and at RIT, 6) build a prototype, and 7) conduct preliminary performance testing. This process will expose students to a multidisciplinary design process with a focus on social and environmental issues.

10. Supplemental Keywords: drinking water, pathogens, viruses, bacteria, innovative technology, renewable, disinfection, engineering, developing countries, solar

Solar Pasteurizer with Integral Heat Exchanger
for Treating Water in Rural Areas

Challenge Definition

Although potable water is critical in sustaining human life, according to the World Health Organization (WHO) and UNICEF water assessment there are over one billion people without access to safe water [1,2]. Every year more than five million people die because of the lack of safe water and improper sanitation. The most profound impact of unsafe water occurs among children below the age of five. A substantial portion of the more than 10 million children who die each year is directly related to unsafe water and poor sanitation [3]. At the 2002 World Summit on Sustainable Development, it was recognized that access to safe water is a severe problem to sustainable growth, so much that the Johannesburg Sustainability Plan of Implementation set a target of halving the proportion of people without access to safe water by 2015 [4]. Although there has been significant progress increasing safe water accessibility in urban areas over the past decades, there is still significant shortage in rural areas of the developing world. According to UNICEF, 50% of the children living in rural areas of the 50 least developed countries do not have access to improved drinking water sources [5]. These less centralized areas are more challenging to address because the disperse nature of the population makes it difficult to utilize centralized water systems and the limited access to the utility grid limits potential technology options. Decentralized water treatment technologies will have to be deployed to satisfy much of this rural need.

Not having access to safe water not only leads to higher death rates but also causes significant debilitating problems such as weakness, blindness, and respiratory illnesses. This lack of access hinders people's ability to focus on the development of their families and communities, which ultimately reduces their chances of improving their economic prosperity. There has been considerable work done on community sized water treatment systems for the developing world where ideally a community could protect a pure, safe source of water by capping a spring or well. Then by utilizing gravity or a pump to deliver the water supply a source of water is available. If a safe source is not available, or

if the source is suspect, a treatment process must be employed. Treatment technologies normally include some type of pretreatment process such as sedimentation and/or roughing filtration followed by one or more treatment processes. Some of these treatment processes include boiling, chemical disinfection (chlorination), slow sand filtration, ultraviolet disinfection, or solar disinfection. These treatment methods may not always be appropriate because of high costs, diminishing fuel supplies, potential environmental degradation, limited access to vital chemicals, significant maintenance, or not having guaranteed disinfection. Since energy from the sun is readily available in most locations where unsafe water is an issue, developing a solar water treatment technology is a viable option for small water supply systems. One solar technology that has gained recent attention is solar water pasteurization.

The objective of this proposal is to create and advise an engineering multidisciplinary student team in designing, building, and conducting preliminary tests of a prototype solar pasteurizer. A novel technological approach is to integrate the solar collection and heat recovery components into a single unit, a Solar Pasteurizer with Integral Heat Exchanger (SPIHX). Integrating the system has the potential to reduce overall cost and increase the robustness of the system. The design will focus on reducing costs and ensuring the solar pasteurizer can be mass produced using developing world accessible fabrication techniques and materials. The student team, in consultation with partners in Venezuela and based on the WHO safe water recommendation, will specify a suitable daily production rate. The SPIHX will be designed to meet the desired load in both tropical and subtropical climates at minimal cost. The system will be designed to require nominal maintenance and have at least lifetime of ten years.

Innovation and Technical Merit

Pasteurization works on the principal that pathogenic protozoan, bacteria and viruses are destroyed as water temperatures are elevated. Water can be pasteurized at much lower temperatures than boiling, therefore reducing the potential emission associated with boiling water for treatment. The pasteurization of water is a function of temperature and exposure time. The most thermally resistant pathogens for short time periods of less than

one hour are the viruses. Most viruses are inactivated in less than one minute above 70°C according to Backer [6]. Hepatitis A appears to have greater thermal resistance than other viruses. Parry and Mortimer found that Hepatitis was fully inactivated within four minutes at 70°C and 30 seconds at 75°C in a phosphate-buffered saline solution [7].

Solar pasteurization emerged as a means of treating water in the mid 1990's. Earliest development utilized a batch process for heating the water to pasteurization temperatures. Theses systems tended to be low cost, but suffered from relatively small production rates (<5 liters/day) [8-11]. The batch systems tend to be simple and are reliable as long as the users are trained properly. The disadvantage of these types of systems is that they require the operator to monitor them throughout the day and replace the water with untreated water once pasteurization temperatures are reached in order to get optimal performance. The entire system must also reach the pasteurization temperature which may be extremely difficult on partly sunny days with larger systems.

To increase performance, flow-through systems were developed, which use a thermostatic valve or other temperature control to regulate a continual flow through the system while ensuring pasteurization temperatures are reached. A natural extension of this design is to add a small heat exchanger to recover heat from the treated water to preheat incoming untreated water. This improvement dramatically increases throughput of systems by a factor of four or more [9]. There are a few off-the-shelf systems that use two separate primary components [12], the solar collector and heat exchanger, which limits options for cost reduction.

If the solar collector and heat exchanger could be integrated with little sacrifice to system performance, the cost and simplicity of the system could be greatly improved. An integrated system can be built by attaching a heat exchanger surface on the underside of an absorber. This approach would eliminate all the components associated with an external heat exchanger such as insulation, housing, and piping material. Because the water is in full contact with the absorber and at low pressures, a wide range of materials and fabrication techniques can be considered to reduce system cost. Preliminary

experimental work on merging the collector with an integral heat exchanger for small water treatment systems has been done [13,14] but little has been done to design deployable prototype systems, which could potentially be manufactured within the country of use.

The proposed student project will apply the knowledge from preliminary work on SPIHX systems to develop a simple and inexpensive prototype that could potentially be mass produced in the developing world. The students will be faced with many design challenges such as passive temperature and flow control, material evaluation and selection, and system robustness. This design process will be highly multidisciplinary in nature requiring a wide range of expertise in the areas of heat transfer, material selection, manufacturing, and cost analysis. The multidisciplinary design team will 1) review the available pasteurizer literature, 2) define appropriate design specifications, 3) review the constraints imposed by resource availability in developing countries, 3) develop a series of integrated solar pasteurizers concepts, 4) select a design concepts to develop further based on appropriate criteria (effectiveness, costs, manufacturability, etc), 5) present design to a scientific review panel and technical partners in Venezuela and at RIT, 6) build prototype, and 7) conduct preliminary performance testing. This process will expose students to a multidisciplinary environment design process with a focus on social and environmental issues.

Sustainability

Having access to safe water in conjunction with proper sanitation will reduce the high mortality rate of children under five as well as increase the time older children are in school according to WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation (2005). Water treatment technologies will better enable children to grow up into productive and contributing members in their communities. The JMP has also shown that improved access to safe water increases the number of productive days for adults as well as reducing the strain on stretched health systems. These benefits are vital first steps in the development of thriving and sustaining communities.

Although there are many water treatment technologies available to improve the quality of life of rural communities, solar pasteurization potentially offers some unique benefits. Solar pasteurization is well suited for small scale remote applications where auxiliary power is not available. Solar pasteurizers also can be fabricated using locally available material and skills, while requiring no specialized imports. For these reasons, the likelihood that the technology will be maintained and adopted readily is greater than many of the alternatives if a small scale cost effective system can be developed.

Measurable Results, Evaluation Method, and Demonstration Strategy

Within RIT's Kate Gleason College of Engineering, graduating engineering students are required to participate in a "capstone" design experience which consists of a two-quarter "Multidisciplinary Design Experience" (MDE). During this experience students from Industrial and Systems Engineering, Mechanical Engineering, and Electrical Engineering form teams to work on projects for a wide variety of clients, thus providing real-world business interactions. The teams may also attract students from disciplines beyond the College of Engineering. Our students consistently blend excellence and entrepreneurship into this experience with over forty teams participating per year. More details of this multidisciplinary experience can be found at the following URL: http://edge.rit.edu. As the team moves forward with their MDE projects, our proposed student team will evaluate their design against the cost and productivity criteria which will include appropriate environmental and social externalities.

During the MDE, which is approximately 22 weeks long, student teams follow the following multi-faceted methodology to solve a design problem:

- Recognize and Quantify the Need
- Concept Development
- Feasibility Assessment
- Establishing Design Objectives and Criteria
- Analysis of Problems & Synthesis into the Design
- Preliminary Design
- Engineering Models - Simulation and/or Hardware

- Detailed Design (DFx)
- Production Planning and Tooling Design
- Pilot Production
- Transition to Commercial Production
- Product Stewardship

Twice during the overall MDE, each student team presents their progress to date to a technical panel of professional engineers from academe and industry. The panel then scrutinizes the design and gives feedback. In addition, for this project the student team will be in direct communication with technical partners in Venezuela to provide regular feedback and a final design review. This will help sensitize the students to issues of fabricating and operating a system in an environment where the systems might ultimately be fabricated and deployed.

During the second half of the MDE, the students will build the solar pasteurizer and complete preliminary testing. A testing protocol will be developed to ensure that pasteurization conditions are met for treated water. This will most likely involve the measurement of temperatures and flow rates under a range of operating conditions. The overall throughput of the system will also be measured for a few days of operation. In addition to experimental assessments, the team will also assess the system based on ease of use and maintainability, product life and end of life considerations, and benign disposal. Finally the team will be responsible for developing a list of recommendations and a cost benefit analysis for future versions of the solar pasteurizer based on their overall assessment.

A more comprehensive evaluation of the system performance will be done by one or two students during the spring quarter of 2007 as an undergraduate independent study. The performance will be monitored by equipping the pasteurizer with instrumentation which will measure real time temperatures, flow rate, and solar resource. This data will aid in ultimately modeling the performance of the system in order to predict its performance under a wide range of climatic conditions.

Integration of P3 Concepts as an Educational Tool

During the MDE, students from Mechanical Engineering, Industrial and Systems Engineering, and Electrical Engineering form teams to work on projects for a wide variety of industrial, government, and academic clients. In the past, teams have also included interested students from other colleges within RIT, including students who major in business, industrial design, and various science departments. Students enrolled in the MDE work through a formal engineering design process to complete their projects as discussed previously. In the proposed project, students will evaluate their conceptual designs against both traditional cost and productivity criteria as well as against broader sustainability criteria. Standard methods and metrics which ignore environmental and social externalities may not be appropriate for a project or product that is to be evaluated against broader sustainability criteria. An important step forward in increasing the awareness of students with respect to the impacts of their designs on people, prosperity and the planet will have been made once awareness of sustainability issues has been assimilated into the standard design process.

This project also will serves as one of the first MDE projects specifically initiated to enhance the new Energy and Environment Option being developed in the Mechanical Engineering department at RIT. This option will consist of a series of electives, co-op experiences, and a MDE that provides students with exposure to a wide range of opportunities and careers associated with energy systems, and how they relate to the environment.

Project Schedule

The first phase of this project will include a senior design MDE followed by an independent study to fully test the system. The second phase of the project would be to improve the initial prototype, field test the improved pasteurizer, initiate preliminary construction in country, and perform more detailed effectiveness and reliability testing. The schedule for the first phase is as follows:

Activity	Sep		Oct		Nov		Dec		Jan		Feb		Mar		Apr		May	
Team startup																		
Scope definition & lit. research																		
Interaction with Venezuela partners																		
Capture of regional constraints																		
Concept development & assess.																		
Preliminary designs																		
Prototype Manufacturing																		
Testing																		
Detailed design and reporting																		
Extensive testing & modifications																		
Final reporting																		
Trip to Washington D.C.																		

Partnerships

There are two partnerships in Venezuela (a university and a NGO) that will provide local support and expertise in the area of water treatment as well as end user requirements, manufacturing and feedback on prototypes. Some of the investigators have been collaborating with these organizations for the past three years. Additionally, there are two local partnerships in Rochester, New York that will provide fabrication assistance and expertise support. These are listed below.

Universidad Catolica Andres Bello (UCAB)
School of Industrial Engineering (Ing° Vicente Napolitano, Department Head)
School of Civil Engineering (Ing° Jose Ochoa Iturbe, Department Head)
Water and Hydraulics Laboratory (Ing° Francisco Morera, Lab Manager)
Edificio de Laboratorios
Avenida General Jose Antonio Paez
Apartado Postal 20332
Urb. Montalban, La Vega. Caracas 1020-A
Venezuela
Telephone: +58-212-407.4150
Email: jochoa@ucab.edu.ve
URL: www.ucab.edu.ve

UCAB is a Catholic University located in Caracas, Venezuela. Some of the investigators at RIT and UCAB have collaborated in the past few years in a number of projects and there are agreements of understanding signed between the two institutions. This university has many contacts and branches into poor rural areas in Venezuela and can assists with future field tests as well as with capturing local feedback. Also, the university boasts excellent water treatment labs and can assist with microbiological testing as well.

Elizabeth Guedez
Project Manager
Centro de Atencion al Niño (CAINA) *–NGO*
Urb Lomas de la Lagunita
Caracas, Venezuela.
Telephone: +(212) 961-4162
Email: eguedez@swfactory.com.ve

Ms. Guedez heads several efforts on children education and gardening in a peri-urban area of Caracas. She has a longstanding relationship with one of the project Co-PIs and, in the past couple of years, has assisted with other sponsored student projects on solar ovens by providing needed contacts in an impoverished area of Venezuela.

National Center for Remanufacturing and Resource Recovery (NCR^3)
Rochester Institute of Technology
Center for Integrated Manufacturing Studies
111 Lomb Memorial Drive
Rochester, NY 14623-5608
Phone: (585) 475-5101
Website: www.reman.rit.edu

The National Center for Remanufacturing and Resource Recovery is located on the campus of Rochester Institute of Technology. Their mission is to deliver to industry advanced technologies and tools for efficient and cost-effective remanufacturing and the design of products that have no negative environmental impacts. This center boasts outstanding research facilities and personnel that can provide support to this project. One of the investigators (Dr. Brian Thorn) has successfully collaborated with this center in the past.

Brinkman Manufacturing Laboratory
Rochester Institute of Technology
Louise M. Slaughter Building
81 Lomb Memorial Drive
Rochester, NY 14623-5603
Phone: (585) 475-6573
Fax: (585) 475-2520
Email: brinkman@rit.edu
Website: www.rit.edu/~brinkman

The Brinkman Manufacturing Lab is a 2000 sq-ft facility located on the campus of Rochester Institute of Technology in Rochester, NY. This facility offers CNC machine tool capabilities, resin casting, electro-discharge machining, and assembly capabilities. Additionally, design software and materials selection software are available in the laboratory. One of the investigators (Dr. Andres Carrano) is the past Director of this facility. This laboratory is where most of the fabrication activities are expected to take place.

References

[1] WHO and UNICEF, *Global Water Supply and Sanitation Assessment 2000 Report*. 2000, available at http://www.unicef.org/wes/index_documents.html.

[2] WHO and UNICEF, *Water for Life : Making it Happen*. 2005, WHO Press, available at www.who.int/water_sanitation_health/monitoring/jmp2005/en/

[3] Black, R.E., S.S. Morris, and J. Bryce, "Where and Why are 10 Million Children Dying Every Year?," The Lancet, 2003. **361**: p. 2226-2234.

[4] United Nations, *Report of the World Summit on Sustainable Development.* 2002: Johannesburg, South Africa, United Nations Publications.

[5] UNICEF, *The State of the World's Children 2006: Excluded and Invisible*, Executive Summary, UNICEF, 2005.

[6] Backer, Howard D. "Field Water Disinfection", *Management of Wilderness and Environmental Emergencies*. Second Edition, St. Louis: The C.V. Mosby Company, 1989.

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[8] Burch, Jay; Thomas, Karen E. *An Overview of Water Disinfection in Developing Countries and the Potential for Solar Thermal Water Pasteurization*. NREL/TP-550-23110, Golden, CO: National Renewable Energy Lab, 1998.

[9] Andreatta, Dale; Yegian, Dale; Connelly, Lloyd; Metcalf, Robert. "Recent Advances in Devices for the Heat Pasteurization of Drinking Water in the Developing World", *1994 29th Intersociety of Energy Conversion Engineering Conference Proceedings*. Vol. 4., Monterey, CA.; pp 1741-1746.

[10] Andreatta, Dale. "Solar Drinking Water Pasteurizer for the Developing World", *Home Power*, 1996, **52**: pp 44-46.

[11] Saye, Roland; Pejack, Edwin. "A Temperature Indicator for Purifying Water", *Developments in Solar Cookers, Proceedings of the Second World Conference on Solar Cookers*. July 12-15, 1994; pp 298-300.

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[13] Stevens, R.J. and Johnson, R.R., "Design and testing of two low-cost solar pasteurizers." *Proceedings of the American Solar Energy Society 1999*, Portland, MN, pp. 125-130, 1999.

[14] Stevens, R.J., Johnson, R.R., and Eckerlin, H.M., "An investigation of a solar pasteurizer with an integral heat exchanger (SPIHX)." *Proceedings of the American Solar Energy Society 1998*, Albuquerque, NM, 1998.

Itemized Budget for EPA STAR Grant Application

CATEGORIES	YEAR ONE		TOTAL PROJECT	
	Federal	Cost Share	Federal	Cost Share
a. Personnel				
Principal Investigator, Stevens			$ -	$ -
Co-PI, Thorn, Carrano, Bailey			$ -	$ -
			$ -	$ -
TOTAL PERSONNEL COSTS	$ -	$ -	$ -	$ -
b. Fringe Benefits				
c. Travel				
R/T ROC - WDC, 3 people X 2 days	$ 2,500		$ 2,500	
			$ -	$ -
TOTAL TRAVEL COSTS	$ 2,500	$ -	$ 2,500	$ -
d. Equipment				
			$ -	$ -
TOTAL EQUIPMENT COSTS	$ -	$ -	$ -	$ -
e. Supplies				
Circular Saw	$ 130		$ 130	
Table Saw	$ 900		$ 900	
16” wood bandsaw	$ 625		$ 625	$ -
Scroll saw	$ 160		$ 160	$ -
Consumables	$ 2,664		$ 2,664	
				$ -
TOTAL SUPPLY COSTS	$ 4,479	$ -	$ 4,479	$ -
f. Contracts				
			$ -	$ -
			$ -	$ -
				$ -
TOTAL CONTRACTUAL COSTS	$ -	$ -	$ -	$ -
g. Other				
			$ -	$ -
			$ -	$ -
				$ -
TOTAL OTHER COSTS	$ -	$ -	$ -	$ -
h. TOTAL DIRECT COSTS	$ 6,979	$ -	$ 6,979	$ -
i. Indirect costs				
43.3% of MTDC	$ 3,021	$ -	$ 3,021	$ -
j. TOTAL PROJECT COSTS	$ 10,000	$ -	$ 10,000	$ -
k. TOTAL REQUESTED FROM EPA	$ 10,000		$ 10,000	

Budget Justification

The funding requested for travel will allow the PI to bring 2 students to Washington, DC in spring 2007 for a conference.

In the supplies category, the tools are itemized above. The consumables to be purchased include materials such as wood, plywood, acrylic, adhesives, and sheet metal.

Rochester Institute of Technology’s federally approved indirect cost rate is 43.3%

Robert J. Stevens, Ph.D.
Assistant Professor
Rochester Institute of Technology
Department of Mechanical Engineering
76 Lomb Memorial Drive
Rochester, New York 14623-5603
(585) 475-2153
rjseme@rit.edu

Professional Preparation

Ph.D. Mechanical & Aerospace Engineering. University of Virginia, Charlottesville, VA. 2005
M.S. Mechanical & Aerospace Engineering. North Carolina State University. Raleigh, NC. 1998
B.S. Engineering, Swarthmore College, PA. 1992

Appointments

- **Assistant Professor**. Rochester Institute of Technology, New York. Department of Mechanical Engineering. 2005-present.
- **Graduate Research Assistant**. University of Virginia, Charlottesville, VA. Microscale Heat Treat Lab, Mechanical Engineering, NSF IGERT Fellow, 2001-2005.
- **Solar Engineering Specialist.** North Carolina Solar Center, Raleigh, NC. 1998-2001.
- **Graduate Research Assistant**. North Carolina State University. Raleigh, NC. North Carolina Solar Center. 1995-1998.
- **Program Associate**. SunShares, Inc., Durham, NC. 1993-1995
- **Research Technician.** GRASP, Inc., Philadelphia, PA 1992-1993.

Publications

i) Closely related publications

- R.J. Stevens and R.R. Johnson, "Design and testing of two low-cost solar pasteurizers." *Proceedings of the American Solar Energy Society 1999*, Portland, MN, pp. 125-130, 1999.
- P. Nyahoro, R.J. Stevens, and J. Grady, "Evaluation of cleaning strategies to be used on a roof integrated solar thermal power system." *Proceedings of the American Solar Energy Society 1999, Portland*, MN, pp. 83-88, 1999.
- R.J. Stevens, R.R. Johnson, and H.M. Eckerlin, "An investigation of a solar pasteurizer with an integral heat exchanger (SPIHX)." *Proceedings of the American Solar Energy Society 1998*, Albuquerque, NM, 1998.

ii) Significant publications

- R.J. Stevens, A.N. Smith, and P.M. Norris, "Measurement of thermal boundary conductance of a series of metal-dielectric interfaces by the transient thermoreflectance technique." *ASME Journal of Heat Transfer* in March 2005.
- R.J. Stevens, P.M. Norris, and L.V. Zhigilei, "Molecular-dynamics study of thermal boundary resistance: evidence of strong inelastic scattering transport channels" *Proceedings of IMECE'04*, Anaheim, CA, November 2004.
- R.J. Stevens, A.N. Smith, A.W. Lichtenberger, and P.M. Norris, "Thermal boundary resistance of thin metal films and thermally conductive dielectric materials." *Proceedings of IMECE'03*, Washington, DC, pp. IMECE2003-41856 1-7, November 2003.
- P.M. Norris, A.P. Caffrey, R.J. Stevens, J.M. Klopf, J.T. McLeskey, and A.N. Smith, "Femtosecond pump-probe nondestructive examination of materials." *Review of Scientific Instruments*, Vol. 74, pp. 400-406, 2003.

Synergistic Activities

- **Teaching Experience,** Introduction to Heat Transfer (RIT, NCSU), Contemporary Issues in Energy and the Environment (developed this course at RIT), Design of Solar Thermal Systems (developed this course at NCSU), and Applied Probability and Statistics (UVA). In addition to teaching at the college level, I developed and taught courses instructing K-12 teachers how to use renewable energy as a means of teaching science, math, and technology. In addition, I trained both architects and contractors in a range of renewable energy technologies.
- **NC MSRI Coordinator**, Directed North Carolina's Million Solar Roofs Initiative, which included organizing public awareness events and training programs, working with community groups to develop local solar projects and initiatives, and providing technical support for the North Carolina public on solar thermal, passive, and building science issues.
- **ASME K21 Heat Transfer Education Committee Member,** Fall 2003 – present, Co-chair of K21 Heat Transfer Education Student Poster session, IMECE 2004
- **Energy and Environment Option Committee,** Co-designing the new Energy and Environment Option in the Mechanical Engineering Department at RIT. This new option will consist of a series of electives, co-op experiences, and a culminating multidisciplinary design experience that provide students with exposure to a wide range of opportunities and careers associated with energy systems, and how they relate to the environment.

Collaborators and other affiliations

i. Collaborators

Dr. Margaret Bailey, Department of Mechanical Engineering, RIT
Dr. Andres Carrano, Department of Industrial and Systems Engineering, RIT
Dr. Michael Klopf, Jefferson National Lab
Dr. Arthur Lichtenberger, Department of Electrical Engineering, University of Virginia
Dr. Jim McLeksey, Department of Mechanical Engineering, Virginia Commonwealth University
Dr. Pamela Norris, Department of Mechanical and Aerospace Engineering, University of Virginia
Dr. Andrew Smith, Department of Mechanical Engineering, U.S. Naval Academy
Dr. Brian Thorn, Department of Industrial and Systems Engineering, RIT
Dr. Leonid Zhigilei, Department of Materials Science and Engineering, University of Virginia

ii. Graduate and Post Doctoral Advisors

Dr. Pamela Norris, University of Virginia (Ph.D. advisor)
Dr. Richard Johnson, North Carolina State University (M.S. Co-Advisor)
Dr. Herbert Eckerlin, North Carolina State University (M.S. Co-Advisor)

iii. Thesis advisor and postgraduate-scholar sponsor

Mr. Carlos Cheek (BS/MS student. Expected graduation 2008).

Margaret B. Bailey

Department of Mechanical Engineering
Kate Gleason College of Engineering, Rochester Institute of Technology
Rochester, New York 14623

voice: (585) 475-2960, fax: (585) 475-7710
email: Margaret.Bailey@rit.edu

A. PROFESSIONAL PREPARATION

The Pennsylvania State University	Architectural Engineering	BS; 1988
University of Colorado at Boulder	Civil, Environmental and Architectural Engineering: Dissertation Title: The Design and Viability of a Probabilistic Based Fault Detection and Diagnosis Method for Vapor Compression Cycle Equipment	PhD; 1998

B. APPOINTMENTS

2003 – present **Kate Gleason Endowed Chair and Associate Professor** of Mechanical Engineering, Kate Gleason College of Engineering, Rochester Institute of Technology, Rochester, NY. *Research areas:* energy conversion system analysis and modeling, exergetic thermodynamic analysis of energy systems, externality and life cycle cost analyses of energy conversion systems, neural network modeling applications, automated fault detection and diagnosis.

1998 – 2003 **Associate Professor** of Mechanical Engineering (promoted to Assoc. Professor August 2003), Department of Civil and Mechanical Engineering, United States Military Academy, West Point, NY.

1997 – 1998 **Assistant Professor**, Department of Civil and Architectural Engineering, University of Wyoming, Laramie, Wyoming

1993 – 1994 **Teaching Assistant,** Department of Architectural Engineering, The Pennsylvania State University, University Park, PA.

1991 – 1993 **Facility Engineer / Project Manager,** Fordham University, New York, NY. *Responsibilities:* Managed campus mechanical projects, Performed project management duties including contract bidding and negotiations on several large projects with budgets in excess of $1million. Prepared RFP's; interviewed and supervised professional consultants; assisted in determining priorities and estimated costs for future capital projects; building and ADA code compliance.

1990-1991: **Associate HVAC Consulting Engineer**, Einhorn Yaffee Prescott Architecture & Engineering, P.C., Albany, NY. Designed mechanical systems for commercial buildings; performed building cooling and heating load analysis; produced contract documents; reviewed shop submittals, conducted site visits and inspections. Worked extensively with energy codes and utility rebate programs.

1988-1990: **Associate Facilities Engineer**, IBM Corporation, Kingston, NY. Assistant project manager on $20 million building abatement and retrofit project. Designed HVAC, piping, and fire protection systems for computer areas, office centers and computer test cells.

C. PUBLICATIONS: *More than 25 technical and educational papers. Five relevant followed by five other*

[1] **Bailey, M.**, Albert, B., Arnas, O., Klawunder, S., Klegka, J., Wolons, D. (2004) "A Unique Thermodynamics Course With Laboratories." International Journal of Mechanical Engineering Education, V. 45, pp. 495-509.

[2] **Bailey, M.**, Arnas, O., Potter, R., Samples, J. (2004) "The 20 Year Evolution of an Energy Conversion Course at The United States Military Academy." Journal of Energy Conversion and Management, to appear in 2004.

[3] **Bailey, M.**, Floersheim, R., Ressler, S. (2002) "Course Assessment Plan: A Tool for Integrated Curriculum Management." Journal of Engineering Education, V. 91, No. 4, pp. 425-434.

[4] **Bailey, M.**, DeBartolo, E. (2005) "Creating a Community for Women Engineers at RIT." Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition, Portland, Oregon, June.

[5] DeBartolo, E., **Bailey, M.** (2005) "A Continuous Series of Outreach Programs to Recruit Young Women to Engineering". Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition, Portland, Oregon, June.

C. PUBLICATIONS: *(continued)*

[6] Arnas, O., Boettner, D., **Bailey, M**. (2003) "On the Sign Convention in Thermodynamics – an Asset or an Evil?" IMECE 2003: Proceedings of International Mechanical Engineering Congress and R&D, Washington, D.C., November.

[7] Painter, J., Adams, A., Hare, J., Albert, B., **Bailey, M**. (2002) "Improving Undergraduate Laboratories Using a Systematic Design Process at the United States Military Academy." Proceedings of ASEE Zone I Conference, West Point, NY, April.

[8] **Bailey, M**., Curtiss, P., Blanton, P., McBrayer, B. (In Review) "Exergetic, Thermal, and Externalities Analyses of a Cogeneration Plant." ASME Journal of Solar Energy Engineering (pending publication).

[9] Nikulshin, V., **Bailey, M**., Nikulshina, V. (In Review) "Thermodynamic Analysis of Air Refrigerator Using an Exergy Graph." Energy, The International Journal (submitted December 2002).

[10] Nikulshin, V., **Bailey, M**., Nikulshina, V. (2002) "Method of Thermoeconomical Optimization on Graphs of Energy Intensive Systems with Pair Interplay of Flows." Proceedings of the 15th International Conference on Efficiency, Costs, Optimization, Simulation and Environmental Impact of Energy Systems, Berlin, Germany, July.

D. SYNERGISTIC ACTIVITIES *Up to five activities*

1. **Recruitment and Retention Programs for Women Engineering Students at Rochester Institute of Technology (PI)** Sponsored by Engineering Information Foundation. This funding allows us to expand and enhance existing innovative programs such as I Built My Computer@ RIT, a unique program that gives first-year women the tools and instruction to build their own personal computers. This activity not only introduces them to engineering faculty and RIT, but also allows them to forge relationships with other women in the program, and build a sense of community as they move toward graduation.
2. **Creation of a Women's Engineering Community at RIT (PI)** Sponsored by New York State Perkins III Initiative Grant. Effort focuses on the special population of women preparing for nontraditional training and employment. The activities' main target area will provide support services for first and second year female engineering students enrolled within engineering programs at RIT. The proposed project focuses on the creation of a community for first and second year female students within engineering with an overarching goal of improving student retention and success in program completion.
3. **Incorporating Mentoring into the 4th Annual Women in Engineering Overnight Shadow Program (PI)** Sponsored by Partners in Mechanical Engineering Program, ASME Board on Minorities and Women Successful gender diversity outreach event involves hosting dozens female high school juniors for an overnight visit at RIT. The faculty and SWE student members come together to host a number of workshops geared towards engaging each attendee one on one in a college classroom environment. A new goal includes promoting the value of mentoring by involving regional professional engineers.
4. **The First Annual United States Military Academy Engineering Exposition (co-PI)** Sponsored by Partners in Mechanical Engineering Program, ASME Board on Minorities and Women
   Event addresses diversity in engineering in the region and at the United States Military Academy. The Mid-Hudson and West Point Student Chapters of ASME and Society of Women Engineers (SWE) promote diversity and strongly encourage membership in engineering-affiliated societies. Both societies invite engineers from regional industries and members of regional engineering societies—specifically women and underrepresented minority engineers—to share with students and faculty some insights into the practice of engineering in today's technology-driven world.
5. **Teaching Experience** (RIT: 9/03 – 2/05, USMA: 6/98 – 9/03, UW: 8/97 – 6/98) G = graduate; U = undergraduate Energy Conversion Systems (U-USMA), Introduction to Mechanical Engineering Design (U-USMA), Thermodynamics (U – RIT/USMA), Advanced Thermodynamics (U – RIT), Dynamic Modeling and Control (U - USMA), Heat Transfer (U-UW/RIT), Building Environmental Systems I & II (U - UW), Fundamentals of Building Core Systems (U - PSU)

E. COLLABORATORS & OTHER AFFILIATIONS

Collaborators: V. Nikulshin, P. Curtiss, J. Kreider, E. DeBartelo, J.Mozrall, M. Anderson, O. Arnas

Advisor: Dr. Jan F. Kreider, (Professor, University of Colorado at Boulder)

Advisees: Completed thesis: Neall Digert (PhD'99); Robert Dodier (PhD'99), Brian Gillis (MS'05), Erin Canfield (BS/MS '05). *Total = 4*

In-Progress thesis: Erin Colquitt (BS/MS'06), Timothy Schriefer (BS/MS '07). *Total = 2.*

Andres L. Carrano, Ph.D.
Assistant Professor
Rochester Institute of Technology
Department of Industrial and Systems Engineering
81 Lomb Memorial Drive
Rochester, New York 14623-5603
(585) 475-6062
alceie@rit.edu

Professional Preparation

Ph.D. Industrial Engineering. North Carolina State University. Raleigh, NC. 2000
M.S. Industrial Engineering. North Carolina State University. Raleigh, NC. 1997
B.S. Industrial Engineering. Universidad Catolica Andres Bello. Caracas, Venezuela. 1993

Appointments

- **Assistant Professor**. Rochester Institute of Technology, New York. Department of Industrial and Systems Engineering. 2000-present.
- **Graduate Research Assistant**. North Carolina State University. Raleigh, NC. Wood Machining and Tooling Research Program. Department of Wood and Paper Science. College of Natural Resources. 1998-2000
- **Graduate Research Assistant**. North Carolina State University. Raleigh, NC. Furniture Manufacturing and Management Center. Department of Industrial Engineering. College of Engineering. 1996-1998
- **Graduate Research Assistant**. North Carolina State University. Raleigh, NC. Precision Engineering Center. Department of Mechanical Engineering. College of Engineering. 1995-1996
- **Instructor**. Universidad Catolica Andres Bello. Caracas, Venezuela. School of Industrial Engineering. 1993-1995.

Research and Teaching Interests

- Green manufacturing, Design for the Environment, sustainable product design
- Surface metrology
- Manufacturing Systems, Facilities Planning and Production Control

Publications

i) Closely related publications

- Plaz C.R., Wood, C.R., Carrano. A.L., and Thorn, B.K. (2005). User-driven design of low-cost, low-impact solar ovens for rural populations in developing countries. (accepted, Journal of Engineering for Sustainable Development - special issue in sustainability)
- Carrano, A.L. and Thorn, B.K. (2005). A multidisciplinary approach to sustainable product and process design. (in review, SME Journal of Manufacturing Systems - special issue in sustainability).
- Thorn, B.K. and Carrano, A.L. "Incorporating sustainable design in the engineering capstone experience". The 2005 Engineers for a Sustainable World (ESW) Conference. October 5-9, 2005. Austin, Texas.
- Thorn, B.K., Carrano, A.L., Wood, C.R., Plaz, C.R., Giunta, M., Villanueva, A, Gasparin, H. "Design, development and deployment of low impact solar ovens for

impoverished populations". (accepted). Industrial Engineering Research Conference, IERC 2006. May 20-24, 2006. Orlando, Florida

- Carrano. A.L., Thorn, B.K., Wood, C.R., Plaz, C.R., Gasparin, H., Guedez, E., Dacarrett, J., Giunta, M., Villanueva, A. "User-driven design of low-cost, low-impact solar ovens for rural populations in developing countries". (abstract submitted). International Solar Cookers Conference. July 12-14, 2006. Granada, Spain.
- Carrano, A.L. and Thorn, B.K. "A multidisciplinary approach to sustainable product and process design ". CIRP International Conference in Manufacturing Engineering Education. pp 43-49. June 22-25, 2005. San Luis Obispo, California.

ii) Other Publications

- Kandlikar, S.G., Schmitt, D., Carrano A.L. and Taylor, J.B. (2005). Characterization of surface roughness effects on pressure drop in single-phase flow in mini channels. *Physics of Fluids* 17:1. American Institute of Physics.
- Carrano, A.L., and Taylor, J.B. Geometric modeling of engineered abrasive processes. (Volume 7, Issue 1, 2005). Journal of Manufacturing Processes. Society of Manufacturing Engineering
- Carrano, A.L., J.B. Taylor, R.L. Lemaster. "Machining induced subsurface damage of wood". Forest Products Journal. 54(1):85-91. 2004
- Carrano, A.L., J.B. Taylor, R. Young, R.L. Lemaster, D. Saloni,. "Fuzzy knowledge-based modeling and statistical regression in abrasive wood machining". Forest Products Journa.l 54(5):66-72. 2004
- Carrano, A.L., J.B. Taylor, R.L. Lemaster. "Parametric characterization of peripheral sanding". Forest Products Journal. 52(9):44-50. 2002
- Taylor, J.B., A.L. Carrano, Y. Fathi. "Parametric Design and Optimization for a Non-Linear Precision X-Y Microstage". Journal of Manufacturing Systems. SME. Vol(19): 229-238. No. 4. 2000.

Synergistic Activities

- Co-advisor (along with Dr. Brian Thorn) to the student team that won first prize award at the 2005 EPA P3 competition with the project "User driven design of mass producible solar ovens for developing countries".
- Co-advisor (along with Dr. Brian Thorn) of the RIT student chapter of "Engineers for a Sustainable World".
- Developing potential RIT undergraduate program in Sustainable Product Design; program will be submitted to the approval process during the 2005-2006 academic year

Professional Societies

- Engineers for a Sustainable World (ESW)
- Forest Products Society (FPJ)
- Society of Manufacturing Engineers (SME)
- Institute of Industrial Engineering (IIE)
- American Society of Engineering Education (ASEE)
- Rochester Industrial and Manufacturing Engineering Society (RIMES)

Brian K. Thorn – Biographical Sketch

a. Professional Preparation

Rochester Institute of Technology; A.A.S.; 1977
Rochester Institute of Technology; B.S.I.E.; 1980
Georgia Institute of Technology; M.S.I.E.; 1982
Georgia Institute of Technology; Ph.D., Industrial and Systems Engineering; concentrations in applied statistical methods, organizational behavior, and information systems; 1990

b. Appointments

Associate Professor; Department of Industrial and Systems Engineering; Rochester Institute of Technology; 1992 – present.

Assistant Professor; Department of Industrial and Manufacturing Engineering; Rochester Institute of Technology; 1986 – 1992.

c. Relevant Publications

Thorn, B.K., Carrano, A.L., Plaz, C.R., and Wood, C.R., Giunta, M., Villanueva, A., Gasparin, H.; Design, Development, and Deployment of Low Impact Solar Ovens for Impoverished Populations; to be included in the *Proceedings of the 15th Industrial Engineering Research Conference*; May, 2006; Orlando, Florida.

Carrano, A.L., Thorn, B.K., Plaz, C.R., and Wood C.R., Gasparin, H., Guedez, E., Dacarrett, J., Giunta, M., Villanueva, A.; User Driven Design of Low Cost, Low Impact Solar Ovens for Rural Populations in Developing Countries; to be included in the *Proceedings of the International Solar Cookers Conference*; July, 2006; Granada, Spain.

Carrano, A.L., and Thorn, B.K.; The Construction of Trend-Free Experimental Plans on Split-Plot Designs; under review, *SME Journal of Manufacturing Systems.*

Thorn, B. K., and Carrano, A. L.; A Multidisciplinary Approach to Sustainable Product and Process Design; under review, *SME Journal of Manufacturing Systems* (special issue in sustainability).

Thorn, B.K., Carrano, A.L., Plaz, C.R., and Wood, C.R. ; User-Driven Design of Low-Cost, Low Impact Solar Ovens for Rural Populations in Developing Countries; under review, *Journal of Engineering for Sustainable Development: Energy, Environment and Health.*

Carrano, A.L., and Thorn, B.K.; The Construction of Multi-Dimensional Trend-Free Experimental Plans on Two Level Split-Plot Designs; *Proceedings of 13th Industrial Engineering Research Conference*, May 2004.

Thorn, B.K., and Carrano, A. L.; Incorporating Sustainable Design In the Engineering Capstone Experience; presented at the *2005 National Conference of Engineers for a Sustainable World*; October 6, 2005.

Thorn, B. K.; A Design Tool to Assist with Selection of Product Retirement Strategy; *Proceedings of 12th Industrial Engineering Research Conference*; May 2003.

Thorn, B. K., and Rogerson, P.; Take It Back; *IIE Solutions*; April 2002.

Thorn, B. K., Becker, M., Haselkorn, M., Jessop, S.; Closing the Loop: Design Tools for Sustainable Products; report submitted by NCRRR to the US Environmental Protection Agency; July 2002.

d. Synergistic Activities

PI on EPA funded student design project to determine feasibility of storing surplus wind turbine energy as hydrogen. 9/2004 – 5/2005.

CoPI on EPA funded student design project to develop prototype mass manufacturable soar ovens for Latin America. 9/2004 – 9/2005.

Developing potential Institute minor in Sustainable Design. Currently seeking funding under NSF's Curricular Reform Program. Proposal submitted 3/2005.

Developing potential RIT graduate program in Sustainable Product Design; program will be submitted to the approval process during the 2005-2006 academic year

Developed professional engineering elective, Lifecycle Costing and Assessment; course first offered Spring 2005.

Developed professional engineering elective, Fundamentals of Sustainable Design; course offered Fall 2002.

Completed sabbatical at the National Center for Remanufacturing and Resource Recovery; 9/1/01 – 6/30/02

e. Collaborators and Other Affiliations

i. Collaborators

Becker, Monica; National Center for Remanufacturing and Resource Recovery
Hensel, Edward; Mechanical Engineering; Rochester Institute of Technology
Jacobs, Paul; Electrical Engineering; Rochester Institute of Technology
Nasr, Nabil; National Center for Remanufacturing and Resource Recovery
Nye, Alan; Mechanical Engineering; Rochester Institute of Technology
Rogerson, Philip; Industrial and Systems Engineering; Rochester Institute of Technology

Current and Pending Support

Investigator: **Robert Stevens**

Support: ☐Current ☒Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Redesign of a low-cost, point-of-use ultraviolet water disinfection device for rural locations in developing countries**
Source of Support: **Environmental Protection Agency (EPA)**
Total Award Amount: **$10,000** Total Award Period Covered: **9/30/2006 - 5/30/2007**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Solar pasteurizer with integral heat exchanger for treating water in rural areas**
Source of Support: **Environmental Protection Agency (EPA)**
Total Award Amount: **$10,000** Total Award Period Covered: **9/30/2006 - 5/30/2007**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Current and Pending Support

Investigator: **Margaret Bailey**

Support: ☒Current ☐Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Development of a Traveling Engineering Activity Kit (TEAK) for Middle and High School Students**
Source of Support: **American Society of Heating, Refrigeration & Air Conditioning Engineers (ASHRAE)**
Total Award Amount: **$5,000** Total Award Period Covered: **9/1/2005 - 5/31/2006**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current ☐Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **VATEA 2005-2006**
Source of Support: **NYS Education Department (NYSED)**
Total Award Amount:**$194,906(PI funded for $28,000)**Total Award Period Covered: **7/1/2005 - 6/30/2006**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current ☐Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Recruitment and Retention Programs for Women Engineering Students at Rochester Institute of Technology**
Source of Support: **Engineering Information Foundation (PI)**
Total Award Amount: **$120,000** Total Award Period Covered: **9/1/2004 - 8/31/2007**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Redesign of a low-cost, point-of-use ultraviolet water disinfection device for rural locations in developing countries**
Source of Support: **Environmental Protection Agency (EPA) (co-PI)**
Total Award Amount: **$10,000** Total Award Period Covered: **9/30/2006 - 5/30/2007**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Solar pasteurizer with integral heat exchanger for treating water in rural areas**
Source of Support: **Environmental Protection Agency (EPA) (co-PI)**
Total Award Amount: **$10,000** Total Award Period Covered: **9/30/2006 - 5/30/2007**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Development of a Minor Program of Study in Sustainable Product Development**
Source of Support: **Environmental Protection Agency (EPA) (co-PI)**
Total Award Amount: **$13,614** Total Award Period Covered: **7/1/2006 - 6/30/2007**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Seminar Series in Sustainable and Social Entrepreneurship**
Source of Support: **National Collegiate Inventors and Innovators Alliance (NCIIA) (co-PI)**
Total Award Amount: **$20,000** Total Award Period Covered: **7/1/2006 - 6/30/2008**

Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current Pending ☐Submission Planned in Near Future ☐*Transfer of Support

Project/Proposal Title: **Creating a new engineering history course: Kate Gleason and other women of power and influence within engineering**

Source of Support: **Patrina Foundation**

Total Award Amount: **$10,000** Total Award Period Covered: **7/1/2005 - 6/30/2006**

Location of Project: **Rochester Institute of Technology**

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Current and Pending Support

Investigator: **Andres Carrano**

Support: ☒Current ☐Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Wood Machining and Tooling Research Program**
Source of Support: **US Department of Agriculture (USDA)**
Total Award Amount: **$5,000** Total Award Period Covered: **12/1/2005 - 6/30/2006**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current ☐Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Abrasive Wood Machining**
Source of Support: **US Department of Agriculture (USDA)**
Total Award Amount: **$12,000** Total Award Period Covered: **9/1/2003 - 7/31/2006**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current ☐Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Design, Development and Implementation of a Low Cost Regionally Appropriate Solar Oven**
Source of Support: **Environmental Protection Agency (EPA)**
Total Award Amount: **$74,647** Total Award Period Covered: **11/1/2005 - 10/31/2006**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Redesign of a low-cost, point-of-use ultraviolet water disinfection device for rural locations in developing countries**
Source of Support: **Environmental Protection Agency (EPA)**
Total Award Amount: **$10,000** Total Award Period Covered: **9/30/2006 - 5/30/2007**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Solar pasteurizer with integral heat exchanger for treating water in rural areas**
Source of Support: **Environmental Protection Agency (EPA)**
Total Award Amount: **$10,000** Total Award Period Covered: **9/30/2006 - 5/30/2007**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Development of a Minor Program of Study in Sustainable Product Development**
Source of Support: **Environmental Protection Agency (EPA)**
Total Award Amount: **$13,614** Total Award Period Covered: **7/1/2006 - 6/30/2007**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Estimation of the Carbon Footprint of Rochester Institute of Technology**
Source of Support: **Environmental Protection Agency (EPA)**
Total Award Amount: **$6,592** Total Award Period Covered: **7/1/2006 - 6/30/2007**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Seminar Series in Sustainable and Social Entrepreneurship**

Source of Support: **National Collegiate Inventors and Innovators Alliance (NCIIA)** Total Award Amount: **$20,000** Total Award Period Covered: **7/1/2006 - 6/30/2008** Location of Project: **Rochester Institute of Technology** Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:
Support: ☐Current ☒Pending ☐Submission Planned in Near Future ☐*Transfer of Support Project/Proposal Title: **Characterization of Roughness Effects on Laminar Flow at Microscale** Source of Support: **National Science Foundation (NSF)** Total Award Amount: **$311,964** Total Award Period Covered: **6/1/2006 - 5/31/2009** Location of Project: **Rochester Institute of Technology** Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Current and Pending Support

Investigator: **Brian Thorn**

Support: ☒Current ☐Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Design, Development and Implementation of a Low Cost Regionally Appropriate Solar Oven**
Source of Support: **Environmental Protection Agency (EPA)**
Total Award Amount: **$74,647** Total Award Period Covered: **11/1/2005 - 10/31/2006**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Redesign of a low-cost, point-of-use ultraviolet water disinfection device for rural locations in developing countries**
Source of Support: **Environmental Protection Agency (EPA)**
Total Award Amount: **$10,000** Total Award Period Covered: **9/30/2006 - 5/30/2007**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Solar pasteurizer with integral heat exchanger for treating water in rural areas**
Source of Support: **Environmental Protection Agency (EPA)**
Total Award Amount: **$10,000** Total Award Period Covered: **9/30/2006 - 5/30/2007**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Development of a Minor Program of Study in Sustainable Product Development**
Source of Support: **Environmental Protection Agency (EPA)**
Total Award Amount: **$13,614** Total Award Period Covered: **7/1/2006 - 6/30/2007**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Estimation of the Carbon Footprint of Rochester Institute of Technology**
Source of Support: **Environmental Protection Agency (EPA)**
Total Award Amount: **$6,592** Total Award Period Covered: **7/1/2006 - 6/30/2007**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending ☐Submission Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Seminar Series in Sustainable and Social Entrepreneurship**
Source of Support: **National Collegiate Inventors and Innovators Alliance (NCIIA)**
Total Award Amount: **$20,000** Total Award Period Covered: **7/1/2006 - 6/30/2008**
Location of Project: **Rochester Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

ADDITIONAL KEY CONTACTS (use as many sheets as needed)

■ Major Co-Investigator: *Individual responsible for the completion of major portions of the proposed work.*

Name:	Andres Carrano
Title:	Assistant Professor
Mailing Address:	81 Lomb Memorial Drive
	Rochester, NY 14623
Phone Number:	585-475-6062
FAX Number:	585-475-2520
E-Mail & Web Address:	alceie@rit.edu

■ Major Co-Investigator: *Individual responsible for the completion of major portions of the proposed work.*

Name:	Margaret Bailey
Title:	Gleason Endowed Chair
Mailing Address:	76 Lomb Memorial Drive
	Rochester, NY 14623
Phone Number:	585-475-2960
FAX Number:	585-475-7710
E-Mail & Web Address:	mbbeme@rit.edu

■ Major Co-Investigator: *Individual responsible for the completion of major portions of the proposed work.*

Name:	Brian Thorn
Title:	Associate Professor
Mailing Address:	81 Lomb Memorial Drive
	Rochester, NY 14623
Phone Number:	585-475-6166
FAX Number:	585-475-2520
E-Mail & Web Address:	bkteie@rit.edu

■ Major Co-Investigator: *Individual responsible for the completion of major portions of the proposed work.*

Name:	
Title:	
Mailing Address:	
Phone Number:	
FAX Number:	
E-Mail & Web Address:	