Purdue's Engineer of 2020
Seed Grant Funding for 2009-2010
Purdue University

Project Title: Incorporating Sustainability Concepts into the Engineering Curriculum

Total Budget Requested: $33,877

Target Attribute(s) to be studied/implemented: Sustainability education for engineers includes aspects of the "technological, economic, and societal challenges" of the *vision* of the Purdue Engineer of 2020. It also intersects with several of the attributes, specifically: ethical responsibility in a global, social, intellectual, and technological context; multidisciplinarity within and beyond engineering; integration of analytical, problem solving, and design skills; and ability to recognize and manage change.

Investigators:

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Incorporating Sustainability Concepts into the Engineering Curriculum
Proposal for 2008 Purdue Engineer of 2020 Seed Grant

A. Project Description:

OVERVIEW

Issues of sustainability are critical to future engineering design and the interaction of engineers with the societal and economic challenges of the next century, yet few undergraduate courses explicitly address important sustainability concepts. These concepts cut across all traditional engineering disciplines and can be included in the course offerings of all schools, particularly within students' design experiences. Rapid incorporation of sustainability concepts across the college is hampered by uncertainty among faculty about how best to select and frame sustainability concepts within their field, and to some extent, by an uncertainty of content knowledge. We request funding for the development and assessment of materials and a college-wide faculty workshop designed to bring concepts of sustainable engineering into courses across the undergraduate curriculum, especially design-centered courses.

INTRODUCTION AND RATIONALE

Broadly defined sustainability has its roots in the UN's "Brundtland Commission report" (WCED, 1987), which put forward as "sustainable development" the actions that provide for current human needs and standard of living without compromising the ability of future citizens to meet their needs. In practical and engineering terms, this often means the implementation of strategies that explicitly recognize non-infinite resource availability, environmental and ecological system disruption, population growth pressures, energy renewability, and limits of natural systems to incorporate pollution without long-term negative impacts. But full sustainability is larger, and needs to include the interdisciplinary aspects of social equity and long-term economic viability along with environmental issues; these three metrics are sometimes called the "triple bottom line." (Abraham, 2006). Sustainable science and engineering as a discipline is similarly broad, and challenges engineers to integrate industrial, social, and environmental processes (Mihelcic et al., 2003).

Sustainability is long-term and systems-wide in its outlook, and the way that engineered objects, processes, and systems are designed can have a long-ranging impact on future needs of natural and social resources, and environmental services. As students learn the design process, it becomes critical that they understand the long-term implications of their design choices. Sustainability becomes an important part of a complete engineering education for the next century, therefore, for several reasons:

- The questions of scale ("long-term" and "systems-wide") matter: the classical metrics of good design (applicability, efficiency, cost, creativity, scalability, flexibility) are still the same in a sustainable engineering mindset, but the scale is different – students need to be taught to ask explicit questions about how these metrics hold up long into the future, and in a global system where the impacts on everyone and everything (not just the immediate client or customer) is considered.
- The Purdue Engineer of 2020 will do his or her professional work in a world of shrinking resources and changing environmental concerns; he or she will be required to work within these constraints and understand the impacts of engineering actions on them.

- Engineering sustainability ideas stress and hone the desired student skills of creative problem-solving, interdisciplinary thinking, and complexity of analysis (these skills are well-represented in the Purdue Engineer of 2020 attributes).
- There is a significant ethical responsibility inherent in sustainable engineering practices (Vesilind et al, 2006); ethical engineering education requires consideration of the impact of a design to others and the broader societal impact of the engineering enterprise.

Considering these characteristics, it is clear that sustainability is, in fact, a prerequisite for good engineering design; this is not a fad concept, but is instead an expression of core values of long-term engineering that recognizes the increasing realization that the long-term and large-scale will be forgotten if not explicitly included in the design process.

A 2003 "Green Engineering" conference[1] developed a widely-used set of sustainable engineering principles (Abraham, 2006), including:

- holistic engineering of processes and products using system-scale analysis
- minimization of resource depletion, waste production, and non-benign processes or materials
- conservation of ecosystems and human health systems
- application of complete life-cycle analysis
- complete integration of local geography and culture into engineering solutions that actively engage communities and stakeholders.

The conference further concluded that achieving sustainable engineering would require significant innovation and creativity, and that all engineers had a duty to inform society of the practices of sustainable engineering. These principles fit with the Purdue Engineer of 2020 Attributes.

Engineering disciplinary societies have recognized the importance of sustainability and released relevant policy statements, including as part of Engineers' Codes of Ethics. The first "fundamental canon" of the ASCE Code of Ethics includes that engineers "shall strive to comply with the principles of sustainable development"; AIChE includes "protect the environment" among the "paramount duties" of engineers; ASME's Code of Ethics instructs engineers to "consider environmental impact and sustainable development"; and NSPE lists as a "professional obligation" the responsibility to "adhere to the principles of sustainable development in order to protect the environment for future generations." (Website addresses for these statements are included in the references section.)

ABET (2009-10 general criteria) includes sustainability issues in at least two of the general student outcome criteria: 3(c) explicitly cites "sustainability" as a design constraint that students should be able to address, and 3(h) stresses the importance of a broad education that allows engineering solutions in societal context, an important aspect of sustainable engineering (ABET, 2008).

Several universities have recognized this importance, and have created new programs addressing sustainability in engineering, including the NSF-supported Center for Sustainable Engineering (CSE) at Carnegie Mellon, a dual-school MS degree in Engineering Sustainable Systems of the College of Engineering and School Natural Resources and Environment at Michigan, a School of Sustainability at Arizona State, and an NSF-supported curricular redesign around the theme of sustainability in the Materials Engineering department at Cal Poly. The 2008 FIE (Frontiers in

[1] "green engineering" and "sustainable engineering" are often used interchangeably, though Abraham (2004) argues a distinction: "sustainable engineering" includes consideration of societal and justice implications of engineers' work, while "green engineering" concentrates exclusively on the technical and environmental aspects.

Education) conference, sponsored by ASEE and IEEE, included a special session on sustainability in engineering education (Prins et al, 2008).

For many of these reasons, sustainability education connects directly with at least five of the attributes of the Purdue Engineer of 2020: open-ended design/problem solving; multidisciplinary within and beyond engineering; integration of analytical, problem solving, and design skills; ethical responsibility in a global, social, intellectual, and technological context; and ability to recognize and manage change.

Because sustainable thinking cuts across all disciplines of engineering, a teaching approach that incorporates its concepts into courses throughout the curriculum is appropriate. Chase and Rowland (2004) first proposed a innovative faculty workshop model in the form of the Ponderosa Project at Northern Arizona University (mirrored by the Piedmont Project at Emory University). In both of these projects, two-day workshops helped faculty learn sustainability tools and concepts, and helped them develop ways to incorporate those ideas in courses across the curriculum. A key characteristic of the workshop was the breadth of the courses: faculty were not developing sustainability-themed courses, they were developing modules or exercises with sustainability themes to add to existing courses in their departments. In this way, students see sustainability as an integral part of the core curriculum, rather than as an added "special interest" or optional course. The workshop model recognizes that faculty are often interested in bringing these concepts into their courses, but need help finding tools and resources. Furthermore, the workshop environment allows faculty to develop ideas collaboratively. The Ponderosa and Piedmont model has been successfully adapted to a number of universities (including to Illinois Wesleyan University by co-PI Hoffmann, Jahiel et al., 2007), though rarely with engineering faculty (the Carnegie Mellon CSE is the notable exception).

Sustainability ideas are particularly relevant to three types of courses in Purdue Engineering, and we plan to target the faculty who teach these courses. These include:

- introductory classes, including those such as ENGR 126 and disciplinary introductory courses;
- engineering fundamentals courses, especially related to materials, which could address the source, lifecycle, and energy requirements of manufacture, manipulation, recycling and disposal of materials in addition to the current focus on material properties;
- design courses, including capstone or senior design projects: these are the places where skills learned through the curriculum are integrated and creativity and problem solving are center-stage; design is by definition systematic (students are no longer reductively looking at only one part, but instead are concentrating on the whole), a hallmark of sustainable engineering.

OBJECTIVES

This proposal seeks to:

- Further the goals of the Purdue Engineer of 2020 related to sustainable engineering and design by encouraging the incorporation of sustainability concepts into courses across the engineering curriculum;
- Fund a faculty workshop and other faculty discussion and development activities that will provide resources, encouragement, support, and expertise needed by faculty to help them incorporate concepts of sustainability into courses across the college's curriculum.
- Perform preliminary assessment on the effectiveness of the workshop model as a mechanism for enhancing faculty knowledge of sustainable engineering, course content related to sustainability, and student awareness and abilities around sustainability; in doing so, help

establish and assess a faculty development model for the incorporation of the universal concepts of Purdue Engineer of 2020 into a variety of courses and curricula.

PROPOSED ACTIVITIES

For this project, we propose to:

1. Develop and collect modules and sustainability resources that may be helpful to Purdue engineering faculty (using as potential sources the CSE database and activities from current sustainability-related courses at Purdue and elsewhere) and share them with the broader community.

2. Develop and facilitate a faculty workshop on the Piedmont/Ponderosa model of presentations, discussion, and brainstorming, with the goal of providing ideas, contexts, cases, modules, and encouragement to help faculty develop the best way to incorporate sustainability into their own particular course. The workshop would last about 1½ days in Summer 2009, and would include presentations from a small number of Purdue faculty who have sustainability expertise and an external facilitator (perhaps from the CSE). Participating faculty members would be required to develop and implement a course assignment or activity for a course that they already teach, and share their activity with the group and with the CSE Digital Library for Sustainable Engineering. Faculty will receive a small stipend in compensation for their time and effort.

3. Organize a faculty learning community (Cox and Richlin, 2004) during the Fall semester 2009, which would involve monthly meetings over the course of the semester, with readings and facilitated discussion about one or more sustainability concept. The community would have a triple focus of providing information to faculty, providing usable resources that faculty can give students, and discussing, sharing, and evaluating ideas for sustainability activities in courses.

EVALUATION, DISSEMINATION, AND FUTURE IMPACT

On a large scale, the implementation of sustainability concepts, like many curricular innovations, will proceed in incremental steps – from the workshop itself to increased faculty knowledge, to changes in courses, to student learning, and finally to impact on students' professional work. Assessment schemes can follow a similar framework of increasing steps, with sequential assessment of participation, satisfaction, learning, application, and impact (Colbeck, 2003). We plan to assess the work of this proposal using the earlier steps of this model, addressing the participation and satisfaction about the workshop (via post-workshop survey), the satisfaction and learning level of the faculty (through faculty surveys after they apply sustainability concepts to their course), and the application of concepts to courses (through a simple count and descriptive analysis of how the courses changed). The higher-level assessment concepts, impact on students and their professional work, are beyond the scope of this one-year project, but present useful and important questions for further externally-supported work.

Project activities and results will be disseminated to the Purdue community in a variety of forms: (1) publicity surrounding the workshop itself; (2) preparation of a report of ideas coming from the workshop published on the DEEE website, which non-participating faculty can use as a resource;

and (3) posters and presentations as associated with the Purdue Engineer of 2020 Seed grant program.

We anticipate that the results from this project will be spread to a wider audience as well, including: (1) presentation at appropriate conferences, such as ASEE; (2) publication of the application of the workshop model into engineering context (the model exists in the literature for science/social science/humanities, but is notably absent for engineering, and the unique challenges and benefits, including tie-in to design, could make it appealing; and (3) incorporation of all projects and developed materials into the CSE Digital Library of Sustainable Engineering (CSE, 2008), which is currently remarkably small – only 15 entries.

The implementation of this workshop and the course activities that arise from it will provide a unique opportunity to seek external funding for assessment of sustainability outcomes in student learning: currently, very little is available in the literature about the attitudes, and knowledge or skill sets of engineering graduates with regard to sustainability – national calls for increasing these skills so not yet have the documentation of successful mechanisms and strategies. Having several sustainability-related courses inserted (or converted) within the Purdue Engineering curriculum would allow it to become a laboratory to ask these questions.

Finally, a successful workshop could provide precedent and a model for continuing workshops that could further spread sustainability (or other Engineer of 2020 attributes). At other universities where this model has been applied, it has proven extremely popular and has led to further workshops, either with different sustainability themes, as repeats in order to reach a broader faculty audience, or with different initiatives entirely. A successful model of the engineering program at Purdue would strengthen external funding applications to support an ongoing project. The IEECI program at NSF would be a particularly appropriate funding source, as “integration of sustainability into engineering education” is specifically listed a main supported aspect in the program synopsis (NSF, 2008). The NSF CCLI program is also appropriate.

B. Timeline and implementation strategy

We intend to hold the faculty workshop during Summer 2009; therefore, planning and recruitment activities for the workshop would begin immediately upon notification of the grant. Major goals for each semester include:

Late spring 2009	Workshop planning, led by Hoffmann. Specific tasks for the spring: • design workshop sessions, gather appropriate materials • identify and recruit external workshop facilitator • advertise and recruit faculty participants from College; specifically target faculty teaching design and materials courses, but welcome all • arrange workshop logistics (location, food, etc.)
Summer 2009	Hold workshop and related activities, begin assessment, and plan for faculty learning communities, with significant contribution from all investigators. Specific tasks: • conduct two-day workshop, likely in early summer (so as to allow faculty time to incorporate ideas into their fall course planning) • assist faculty participants in their module development for courses • perform initial assessment of workshop – participation and satisfaction • design and plan faculty learning community meetings for fall
Fall 2009	Faculty begin to apply sustainability concepts from the workshop to their classes. Specific tasks for the project, led by Hoffmann: • coordinate with faculty as they apply new modules to their courses • organize and hold faculty learning community meetings with workshop participants (or others), to continue to provide ideas, support and discussion opportunities. • collect, write descriptions, and disseminate course materials and modules to the larger college community • perform initial assessments on the extent and goals of modules, and description of how they developed from workshop goals and activities • seek external funding for future workshops and/or future assessment, as appropriate, using preliminary results
Spring 2010	Wrap up the project. Specific tasks: • coordinate with faculty who are applying modules to spring courses • complete the collection and disseminate the full list of courses impacted and teaching modules developed • continue to seek external funding (NSF/IEECI proposals are typically due in March)

C. Personnel Requirements
Please indicate the portion of FTE that each faculty member will dedicate to the project

Faculty member	Summer 2009	Fall 2009	Spring 2010
Stephen Hoffmann	25% (one week)	10%	10%
Chip Blatchley	25% (one week)	—	—
Inez Hua	25% (one week)		
Larry Nies	25% (one week)	—	—

D. Budget
The budget worksheet is provided to assist you in developing your budget. You may fill this out and paste it directly into your proposal.

Faculty/Staff Member Funding Please indicate the funding (dollars and time) you are requesting for the grant for this project)			
	Grant funds requested		
Faculty/Staff Name:	% Time	Fringe Benefits	$$
Chip Blatchley	25	$1,051	$2,774
Inez Hua	25	$1,130	$2,981
Larry Nies	25	$946	$2,495
Subtotal Faculty/Staff Funding		$3,127	$8,250

Graduate Students				
	Grant funds requested			
Type of position	% Time	Insurance + Fee Remit	Fringe Benefits	$$
none				
Subtotal Graduate Student Personnel		$ 0.00	$ 0.00	$ 0.00

Undergraduate Student Funding *Please indicate the student resources (funding and time) you are requesting from the grant for this project.*			
	Grant funds requested		
Type of position	Hrs/week	Fringe Benefits	$$
none			
Subtotal Undergraduate Student Personnel			

Equipment $ Software Funding *Please list all specialized equipment and software required for the project. (Do not include standard computer equipment and commonly-available software, e.g. Microsoft Office, Microsoft Windows). Mark whether any of the equipment or software is provided by the department. (Note that only 10% of the funds can be used to purchase equipment and it needs to be dedicated to the goals of the project.*	
Name of Equipment	Funds Requested
none	
Subtotal Equipment	$0.00
Name of Software	

none	
Subtotal Software	$0.00
Other miscellaneous items (Computer media, cables, etc)	
none	
Subtotal miscellaneous	$0.00
Other expenses	
Workshop Faculty Stipends	$15,000
Workshop costs: room fees, food (lunches/snacks), printed materials and other hand-out resources	$3,000
Workshop: External facilitator travel, lodging, food, and honorarium	$2,000
Faculty Learning Community: meeting refreshments, printed materials, books	$1,000
Travel: Two workshop leaders to Center for Sustainable Engineering training or AEESP conference	$1,500
Subtotal other expenses	$22,500

E. Budget Justification

Personnel: For the three faculty members (Drs. Blatchley, Hua, and Nies), we request support consistent with their contribution level to this project; they will be involved in strategic decisions and idea formation during the spring, and then actively involved in the delivery and facilitation of the workshop in summer. Dr. Hoffmann will lead the project, using his experience in similar sustainability-related faculty development at Illinois Wesleyan University. His position description at DEEE explicitly includes assisting in "curriculum development related to environmental sustainability with other Schools in the College of Engineering," so salary for his contribution to this project will be covered by DEEE.

Faculty Stipends: Similar workshops at other universities have found it extremely helpful for participant recruitment to offer a small stipend, particularly if the workshop takes place in the summer. We propose a $250 stipend for attendance at the workshop, plus an additional $250 after an activity or module to be incorporated into a course has been submitted to the workshop organizers. The budget will therefore allow for 30 faculty participants.

Other expenses: Other estimated expenses include logistical costs for the workshop and faculty learning community meetings, printing costs and potentially book costs for distributed material to the participants, and travel and modest honorarium costs related to an external facilitator for the workshop. Finally, we have included money for travel for two of the workshop leaders to either a CSE workshop on sustainable engineering (scheduled for June 2009 in Pittsburgh) or the AEESP (Association of Environmental Engineering and Science Professors) annual conference (scheduled for July 2009 in Iowa City). Goals for this project at both meetings would include gathering resources and ideas, and presenting our experiences and results.

F. References cited

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Mihelcic, J.R., J.C. Crittenden, M.J. Small, D.R. Shonnard, D.R. Hokanson, Q. Zhang, H. Chen, S.A. Sorby, V.U. James, J.W. Sutherland, and J.L. Schnoor, 2003, "Sustainability Science and Engineering: The Emergence of a New Metadiscipline," *Environmental Science and Technology*, **37** (23), 5314-5324.

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NSPE (National Society of Professional Engineers) Code of Ethics, accessed December 7, 2008, at http://www.nspe.org/Ethics/CodeofEthics/index.html

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(a) Professional Preparation

B.S.	University of Illinois	Chemistry	1994
Ph.D.	University of Wisconsin	Environmental Chemistry and Technology	2002

(b) Appointments

August 2008 – present	Director of Academic Programs, Division of Environmental and Ecological Engineering, Purdue University
August 2003 – July 2008	Assistant Professor of Chemistry and Environmental Studies, Illinois Wesleyan University
August 2002 – July 2003	Visiting Assistant Professor of Chemistry and Environmental Studies, Illinois Wesleyan University

(c) Publications and presentations

Related to this proposal:

A. Jahiel, S.R. Hoffmann, G. Harper, L. Kunce, V. Miller, C. Kawakita, and Z. Drici, 2007, "Integrating Sustainability into Higher Education at Illinois Wesleyan University," presented at Greening the Campus VII, Ball State University, Muncie, IN, September.

Other important publications:

Hoffmann, S.R., M.M. Shafer, D.E. Armstrong. 2007. " Strong Colloidal and Dissolved Organic Ligands Binding Copper and Zinc in Rivers," *Environ. Sci. Technol.*, **41**, 6996.

Shafer, M.M., S.R. Hoffmann, J.T. Overdier, D.E. Armstrong. 2004. "Physical and Kinetic Speciation of Copper and Zinc in Three Geochemically Contrasting Marine Estuaries," *Environ.Sci. Technol.* **38**, 3810.

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(d) Synergistic activities

i) Other current research projects (continuation of work at IWU)

- Analysis of heavy metal and pesticide residues in kidney tissue from grey wolves of the boreal forest of US and Canada
- Development of biodiesel-based laboratories in undergraduate education: students experimental development for courses at all undergraduate levels and implications for sustainability.

ii) Participant in NSF "New Approaches and Techniques for Teaching Science" workshops.

iii) Member of PKAL (Project Kaleidoscope) Faculty for the 21st century ("F-21")

(e) Collaborators and Other Affiliations (last 48 months)
Collaborators and Co-editors:
Illinois Wesleyan University: R.G. Harper, A. Jahiel, J. Frick, R. Roesner, E. Balser
Illinois State University: G. Jin, T. Bierma
Heartland College: J. Muench
University of Wisconsin-Madison: D.E. Armstrong, C.L. Babiarz, M.M. Shafer

Graduate (doctoral) advisor: Dr. David E. Armstrong, University of Wisconsin-Madison

Thesis Advisor: Undergraduate students at IWU: S. Smith, M. McAvoy, K. Lingen, N. Smoter, B. Wall, J. Koval, K. Eblin (*nee* Billings), W. Palmisano

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NOTE: Dr. Hoffmann has no current or pending support to report.

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(a) Professional Preparation

Purdue University	Civil (Environmental) Engineering	BS, 1981
University of California, Berkeley	Civil (Environmental) Engineering	MS, 1983
University of California, Berkeley	Civil (Environmental) Engineering	PhD, 1988

(b) Appointments

Aug 1999 – Present	Professor, School of Civil Engineering, Purdue University
Jan 2003 – May 2004	Fellow, Northeast-Midwest Institute, Washington, DC
July 1994 – Aug 1999	Associate Professor, School of Civil Engineering, Purdue University
Aug 1995 - June 1996	Visiting Scientist (Sabbatical), CIRSEE, Lyonnaise des Eaux, Le Pecq, FR
Sept 1988 - June 1994	Assistant Professor, School of Civil Engineering, Purdue University

(c) Recent Publications

1. Blatchley III, E.R.; Shen, C.; Naunovic, Z.; Lin, L.; Lyn, D.A.; Robinson, J.P.; Ragheb, K.; Grégori, G.; Bergstrom, D.E.; Fang, S.; Guan, Y.; Jennings, K.; Gunaratna, N. (2006) "Dyed Microspheres for Quantification of UV Dose Distributions: Photochemical Reactor Characterization by Lagrangian Actinometry," *Journal of Environmental Engineering, ASCE*, **132**, 11, 1390-1403.

2. Blatchley III, E.R.; Gong, W.L.; Alleman, J.E.; Rose, J.B.; Huffman, D.E.; Otaki, M.; Lisle, J.T. (2007) "Effects of Wastewater Disinfection on Waterborne Bacteria and Viruses," *Water Environment Research*, **79**, 1, 81-92.

3. Raikow, D.F.; Reid, D.F.; Blatchley III, E.R.; Jacobs, G.; Landrum, P.F. (2007) "Effects of Proposed Physical Ballast Tank Treatments on Aquatic Invertebrate Resting Eggs," *Environmental Toxicology and Chemistry*, **26**, 4, 717-725.

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5. Li, J.; Blatchley III, E.R. (2007) "Volatile Disinfection Byproduct Formation Resulting from Chlorination of Organic-Nitrogen Precursors in Swimming Pools," *Environmental Science & Technology,* **41**, 19, 6732 -6739.

6. Pennell, Kelly G.; Aronson, A.I.; Blatchley III, Ernest R. (2008) "Phenotypic Persistence and External Shielding (PPES) Ultraviolet Radiation Inactivation Kinetic Model," *Journal of Applied Microbiology*, **104**, 4, 1192-1202.

7. Blatchley III, E.R.; Shen, C.; Scheible, O.K.; Robinson, J.P.; Ragheb, K.; Bergstrom, D.E.; Rokjer, D. (2008) "Validation of Large-Scale, Monochromatic UV Disinfection Systems Using Dyed Microspheres," *Water Research*, **42**, 3, 677-688.

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9. Pennell, K. G., Z. Z. Naunovic, and E. R. Blatchley III (2008) "Sequential Inactivation of *Bacillus subtilis* Spores with UV Radiation and Iodine," accepted for publication in *Journal of Environmental Engineering*, ASCE.

10. Fang, S.; Guan, Y.; Blatchley III, E.R.; Shen, C.; Bergstrom, D.E. (2008) "Conjugation of (*E*)-5-[2-(Methoxycarbonyl)ethenyl]cytidine to Hydrophilic Microspheres: Development of a Mobile Microscale UV Light Actinometer," *Bioconjugate Chemistry*, **19**, 592-597.

(d) Synergistic Activities

Professor Blatchley is involved in several collaborative research efforts within and beyond Purdue University. These efforts allow research to be conducted in areas that are at the intersection of several fields. Examples are listed below:

- Development of actinometry systems (in collaboration with researchers from the School of Veterinary Medicine and the Department of Medicinal Chemistry at Purdue University) – research in this area has involved principles of basic and analytical chemistry. Actinometers have been developed that can be applied in homogeneous aqueous solutions and via conjugation with solid surfaces.
- Responses to biological warfare agents (in collaboration with researchers from the Department of Biological Sciences, Purdue University) – characterized physical disinfectants in terms of the potential use in response to incidents involving contamination of water and surfaces by biological warfare agents.
- Management of Ballast Water (in collaboration with researchers from the University of Washington, the University of Wisconsin, the US Geological Survey, and the Northeast-Midwest Institute) – research is ongoing to develop ship-board and port-based methods for treating ballast water in commercial ships to limit the potential for invasions of non-indigenous aquatic organisms.

(e) Collaborators and Other Affiliations (Last 48 months)

Collaborators and Co-Editors

Purdue University
School of Civil Engineering: James, E. Alleman, M. Katherine Banks, Dennis A. Lyn, Loring F. Nies
Chemistry Department: R. Graham Cooks, Hilkka I. Kenttämaa
Department of Biological Sciences: Arthur I. Aronson, Irwin Tessman
Agronomy Department: Cliff T. Johnston, A. Paul Schwab
Department of Medicinal Chemistry: Donald E. Bergstrom
School of Veterinary Medicine: J. Paul Robinson, Katherine Ragheb, Gérald Grégori
University of Washington
Department of Aquatic and Fishery Sciences: Russell P. Herwig, Jeff R. Cordell
Michigan State University
Department of Fisheries and Wildlife: Joan B. Rose
University of South Florida
Department of Biological Oceanography: Debra Huffman
US Geological Survey:
Western Fisheries Research Center (Marrowstone Marine Field Station): Nancy Elder
Center for Coastal & Watershed Studies: John T Lisle
Northeast-Midwest Institute (Washington, DC): Allegra Cangelosi, Nicole Mays
US Environmental Protection Agency: Sam Hayes, Keith Kelty

Graduate Advisors

Jerome F. Thomas, Ph.D., Professor Emeritus, Department of Civil and Environmental Engineering, University of California, Berkeley, CA

Christian G. Daughton, Ph.D., Chief, Environmental Chemistry Branch, Environmental Chemistry Division, USEPA National Exposure Research Laboratory, Las Vegas, NV

Thesis Advisor and Post-Graduate Advisor Sponsor (Purdue University)

Lindsay Brewster, Martina Donnermair, Woei-Long Gong, Anna Lyssandridou, Dimitris Margetas, Anne Meeusen, Zorana Naunovic, Marianne Nyman, Kelly Pennell, Keith Sears, Chengyue Shen, Isaac Wait

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Ernest (Chip) Blatchley	Other agencies (including NSF) to which this proposal has

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:
Challenge Organisms for Inactivation of Viruses by UV Treatment

Source of Support: AWWARF (American Water Works Association Research Foundation)
Total Award Amount: $834,180 Total Award Period Covered: Jan 2006 – March 2009
Location of Project: Purdue University
Person-Months Per Year Committed to the 1.0 Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:
Disinfection of Water and Air Subject to Constraints of Extended Space Travel

Source of Support: NASA
Total Award Amount: $500,000 Total Award Period Covered: Dec 2003 – November 2009
Location of Project: Purdue University
Person-Months Per Year Committed to the 1.0 Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:
Reactions Between Free Chlorine and Reduced Nitrogen: Effects on Water and Air Chemistry in Indoor Swimming Pools
Source of Support: American Chemistry Council
Total Award Amount: $133,750 Total Award Period Covered: June 2008 – May 2009
Location of Project: Purdue University
Person-Months Per Year Committed to the 1.0 Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:
Combined Application of UV Radiation and Chlorine for Recreational Waters: Synergistic Effects and Field Monitoring
Source of Support: National Swimming Pool Foundation
Total Award Amount: $135,303 Total Award Period Covered: Sept 2008 – August 2009
Location of Project: Purdue University
Person-Months Per Year Committed to the 1.0 Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:
Trojan Technologies PhD Student Fellowship

Source of Support: Trojan Technologies, Inc., (London, Ontario, Canada)
Total Award Amount: $26,000/year Total Award Period Covered: 2007 - present
Location of Project: Purdue University
Person-Months Per Year Committed to the Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

INEZ HUA, Ph.D.
Professor, School of Civil Engineering
Interim Head, Division of Environmental and Ecological Engineering
Purdue University, West Lafayette, IN 47907

(a) Professional Preparation

California Institute of Technology, Pasadena	Environmental Science and Engineering	PhD	1996
California Institute of Technology, Pasadena	Environmental Science and Engineering	MS	1992
University of California, Berkeley	Biochemistry	BA	1990

(b) Academic Appointments

August 2007 – present	Full Professor, School of Civil Engineering, Purdue University
July 2006 – present	Founding Interim Head, Division of Environmental and Ecological Engineering, Purdue University
August 2001 – present	Associate Professor, School of Civil Engineering, Purdue University
January 1996 – August 2001	Assistant Professor, School of Civil Engineering, Purdue University

Non-Academic Appointments

June - August 2004	NASA/ASEE Faculty Fellowship (first and second year award)
June - August 2003	NASA Ames Research Center, Mountain View, CA
July – December 2002	Sabbatical leave - U. S. Environmental Protection Agency, Region 9 Headquarters, San Francisco, CA
September 1990- December 1995	California Institute of Technology, Pasadena, CA Graduate research assistant
June-September 1990; June-January 1990	The Dow Chemical Company, Pittsburgh, CA Intern
May-September 1998; January-May 1989	Department of Chemistry University of California, Berkeley, CA Undergraduate Research Assistant
May-August 1986	Lawrence Berkeley Laboratory, Berkeley, CA Intern

(c) Publications

Ten selected publications

1. Nienow, A. M., Bezares-Cruz, J.C., Poyer, I.C., Hua, I., Jafvert, C.T., **Hydrogen Peroxide-Assisted UV Photodegradation of Lindane,** Chemosphere 72(110), 2008.
2. Kang, N., Hua., I., Rao, P. S. C., **Enhanced Fenton's Destruction of Non-aqueous Phase Perchloroethylene in Soil Systems**, *Chemosphere*, 63(10), pp. 1685-1698, 2006.
3. *Zhai, X*., Hua, I., Rao, P. S. C., Lee, L. S., **Co-solvent Enhanced Chemical Oxidation of Perchloroethylene by Potassium Permanganate**, *Journal of Contaminant Hydrology*, 82(1-2), pp. 61-74, 2006.
4. Ahn, M.-Y.; Filley, T. R.; Jafvert, C. T.; Nies, L.; Hua, I.; *Bezares-Cruz, J*., **Photodegradation of Decabromodiphenyl Ether Adsorbed onto Clay Minerals, Metal Oxides, and Sediment**, *Environ. Sci. Technol.* 40(1), pp. 215-220*,* 2006.
5. Ahn, M.-Y.; Filley, T. R.; Jafvert, C. T.; Nies, L.; Hua, I.; **Birnessite Mediated Debromination of Decabromodiphenyl Ether**, *Chemosphere* 64(11), 1801-1807, 2006.
6. Kang, N., Hua, I., Xiao, C., **Impacts of Sonochemical Process Variables on Number Average Molecular Weight Reduction of Asphaltene,** *Industrial and Engineering Chemistry Research,* 45(15), 5239-5245, 2006.

7. Kang, N., and Hua, I., **Fenton oxidation of BTEX Compounds in Soil Slurry Systems**, *Chemosphere*, 61(7), pp. 909-922*,* 2005.
8. *Bezares-Cruz, J*., Jafvert, C., Hua, I*.,* **Solar Photodecomposition of Decabromodiphenyl Ether: Products and Quantum Yield**, *Environmental Science and Technology*, 8(15), pp. 4149 -4156, 2004
9. Kang, N., Hua, I., Rao, P. S. C., **Production and Characterization of Encapsulated Potassium Permanganate for Sustained Release as an In Situ Oxidant,** *Industrial and Engineering Chemistry Research*, 43 (17), pp. 5187 -5193, 2004
10. Zhang, G. and Hua, I.; **Supercritical Water Oxidation of Nitrobenzene,** *Industrial and Engineering Chemistry Research,* 42 (2), pp. 285-289, 2003.

(d) Synergistic Activities

(i) Member of the committee: Management and Effects of Coalbed Methane Development and Produced Water in the Western United States, Board on Earth Sciences and Resources, Water Science and Technology Board, **The National Academies** (2008).

(ii) Chair, Proposal Review Panel, SBIR Environmental Monitoring and Remediation (ZRG1 BST-G (11)), **National Institutes of Health,** (2008).

(iii) Member, Committee for the Technical Assessment of Environmental Programs at the Los Alamos National Laboratory, Nuclear and Radiation Studies Board, **The National Academies** (2006).

(iv) Participant in a multi-stakeholder partnership organized by the **U.S. EPA** Design for Environment (DfE) Program to examine environmental effects of flame retardants in specific applications (2006).

(v) Member of a review panel convened by the **U.S. Department of Energy** to review various aspects of the Environmental Molecular Sciences Laboratory (EMSL) of Pacific Northwest National Laboratory (2005).

(e) Collaborators and Other Affiliations

Collaborators and Co-Editors:

Purdue University: C. Jafvert, L. Nies, T. Filley, L. Lee, P.S.C. Rao, R. Mohtar, M. Helgesen, R. Turco, H. Acuna-Ochoa, M. Sepulveda, L. Raymond, C. Handwerker, J. Strobel
NASA Ames (Mountain View, CA): L Iraci
University of West Florida: J.A. Stuart Williams
Rochester Institute of Technology: T. Seager
University of Alaska: T. Sutton

Graduate (doctoral) advisor: Dr. Michael R. Hoffmann, California Institute of Technology

Thesis Advisor and Post-Doctoral Scholar Sponsor:

Graduated with thesis MS or PhD: U. Pfalzer-Thompson (MS), J. Baldwin (*nee* Schramm) (PhD), M. Beckett (PhD), G. Zhang (PhD), N. Kang (PhD), X. Zhai (PhD)

Post-doctoral scholars: Jose Duque Fabrega, Mi-Youn Ahn, Amanda Nienow, Jeonghyub Ha

Currently supervising or cosupervising: Brianna Dorie, Yin-Ming Kuo, Cesar Bezares, Irene Poyer.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Inez Hua	Other agencies (including NSF) to which this proposal has

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

Project/Proposal Title:

Photochemical Fate of Manufactured Carbon Nanomaterials in the Aquatic Environment

Source of Support: US EPA

Total Award Amount: $199,900 Total Award Period Covered: August 2007 – July 2009

Location of Project: Purdue University

Person-Months Per Year Committed to the Cal: Acad: Sumr: 1.0

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

Project/Proposal Title:

Students' Attitudes and Threshold Concepts Towards Engineering as an Environmental Career: Research by Participatory Design of an Educational Game

Source of Support: Purdue Engineer of 2020 Seed Grant

Total Award Amount: $50,043 Total Award Period Covered: July 2008 – June 2009

Location of Project: Purdue University

Person-Months Per Year Committed to the 0.0 Cal: Acad: Sumr:

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

Project/Proposal Title:

MUSES: Life-Cycle and Policy Aspects of Brominated Flame Retardants

Source of Support: NSF

Total Award Amount: $412,000 Total Award Period Covered: Sept 2005 – Aug 2009

Location of Project: Purdue University

Person-Months Per Year Committed to the Cal: Acad: Sumr: 1.0

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

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

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

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

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

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

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

LORING NIES, Ph.D.
Associate Professor, School of Civil Engineering
Purdue University, West Lafayette, Indiana 47907

(a) Professional Preparation

Michigan State University	Chemistry	B.A.	1982
Michigan State University	Civil Engineering	B.S.	1987
University of Michigan	Environmental Engineering	M.S.E.	1989
University of Michigan	Environmental Engineering	Ph.D.	1993

(b) Appointments

2000-present	Associate Professor, School of Civil Engineering, Purdue University
1993-2000	Assistant Professor, School of Civil Engineering, Purdue University
1988-1993	Graduate Research Assistant, Department of Civil and Environmental Engineering, University of Michigan
1988-1990	Graduate Teaching Assistant, Department of Civil and Environmental Engineering, University of Michigan
1986-1987	Process Engineer, General Motors, Buick Oldsmobile Cadillac Division, Lansing, MI
1985-1986	Laboratory Technician, General Motors, Buick Oldsmobile Cadillac Division, Lansing, MI

(c) Publications – 5 most relevant/5 other

Nyberg, L., R.F. Turco and L. Nies. 2008. Assessing the Impact of Nanomaterials on Anaerobic Microbial Communities. *Environmental Science and Technology*, 42:1938-1943.

Tokarz, J.A., M-Y. Ahn, J. Leng, T.R. Filley, and L. Nies. 2008. Reductive Debromination of Polybrominated Diphenyl Ethers in Anaerobic Sediment and a Biomimetic System. *Environmental Science and Technology*, 42:1157-1164.

Liu, J., L.S. Lee, L.F. Nies, C.H. Nakatsu and R.F. Turco. 2007 Biotransformation of 8:2 Fluorotelomer Alcohol in Soil and by Soil Bacteria Isolates. *Environmental Science and Technology.* 41:8024-8030.

Choi, J.K., L.F. Nies and K. Ramani. 2008. A framework for the integration of environmental and business aspects toward sustainable product development. *Journal of Engineering Design*. In Press.

Tong, Z., M. Bischoff, L.F. Nies, B. Applegate, and R.F. Turco. 2007. Impact of Fullerene (C60) on a soil microbial community, *Environmental Science and Technology*. 41:2985-2991

Baldwin, B. R., C.H. Nakatsu, and L. Nies. 2008. Enumeration of Aromatic Oxygenase Genes to Evaluate Monitored Natural Attenuation at Gasoline-contaminated Sites. *Water Research*, 42:723-731.

Ahn M-Y., C. T. Jafvert, L. Nies, I. Hua, and T.R. Filley . 2006. Birnessite mediated debromination of decabromodiphenyl ether, *Chemosphere*. 64:1801-1807.

Ahn, M-Y., T.R. Filley, C.T. Jafvert, L. Nies, I. Hua, and J. Bezares-Cruz. 2005. Photodegradation of Decabromodiphenyl Ether Adsorbed onto Clay Minerals, Metal oxides and Sediment. *Environmental Science and Technology*. 40:215-220.

Baldwin, B. R., C.H. Nakatsu, and L. Nies. 2003. Detection and Enumeration of Aromatic Oxygenase Genes by Multiplex and Real-time PCR. *Applied and Environmental Microbiology*, 69:3350-3358.

Mesarch, M., C.H. Nakatsu, and L. Nies. 2000. "Development of Catechol 2,3-Dioxygenase-Specific Primers for Monitoring Bioremediation by Competitive Quantitative PCR." *Applied and Environmental Microbiology*, 66:678-684.

(d) Synergistic Activites

Undergraduates Mentored in Research Experience
·Steven M. Alderete, 1993; ·Timothy M.C. La Breche, 1993; ·Michael A. Olvera, 1993; ·Michael J. Sukay, 1993; ·Susana Berríos, 1994 (summer MARC/AIM); ·Christina Lester, 1995; ·Kimberlee Talbot, 1996; ·Tim Thompson, 1996;·Claudia Kneller, 1997; ·Nicole Tompkins, 1997; ·Gina Ishida, 1998; ·Julie Meszaros, 1998; ·Jennifer E. López, 1999 (summer MARC/AIM); ·Edgardo L. Sanabria-Valentín, 2000 (summer MARC/AIM);·John Tokarz, 2001; ·Rebecca Lee-Yan Hong, 2002, Vicki Waranowski, 2005 (SURF)

Synergistic Activities Related to this proposal:
— Shruti Mishra, Summer 2008. Impact of PEGylated Single-Walled Nanotubes on Anaerobic Microbial Community Structure using PCR-DGGE and Group-Specific Primers. Co-authors: Leila Nyberg Ronald F. Turco and Loring Nies. Poster presentation at the "Nanotechnology and the Environment Conference" Indianapolis, IN, August 5-6, 2008.
— Saiya Sheth, Summer 2008. Impact of PEGylated Single-Walled Nanotubes (SWNT) on Anaerobic Microbial Community Function. Co-authors: Leila Nyberg, Loring Nies, Ronald F. Turco. Poster presentation at the "Nanotechnology and the Environment Conference" Indianapolis, IN, August 5-6, 2008.
— Rachel Gatz, Summer 2008. Hydrolysis of Ester Linked Polyethylene Glycol from Single Walled Nanotubes. Co-authors: Chia-Ying Chen, Chad Jafvert, Leila Nyberg and Loring Nies. Poster presentation at the "Nanotechnology and the Environment Conference" Indianapolis, IN, August 5-6, 2008.

(e) Collaborators and Other Affiliations

Collaborators and Co-Authors:
Purdue University: E. Blatchley, T. Filley, I. Hua, C. Jafvert, L. Lee, C. Nakatsu, R. Turco, S. Rao
Renssalaer Polytechnic Institute: Marianne Nyman
Rice University: P. Alvarez
US EPA: C. Enfield
Industry: B. Baldwin (Microbial Insights); A. Frisbie (Wabash National); J. Leng (HDR Engineering); M. Mesarch (Montgomery Watson); J. Simonds (Handex)

Graduate Thesis Advisor: Timothy Vogel, University of Lyon, France

Recent Thesis Students Advised: Anna Bargalló, M.S.E.; Paul Bonus, M.S.C.E.; Andrew Frisbie, Ph.D.; Junfeng Leng, Ph.D.; Matthew Mesarch, Ph.D. (co-advised with C.H. Nakatsu); Robin Ridgway, Ph.D.; Brett Baldwin, PhD, (co-advised with C.H. Nakatsu); Tianbo Xu, PhD, (co-advised with L.S. Lee); Leila Nyberg, M.S. (current PhD student)

Total Graduate Students advised since 1993 is 18 thesis students and 20 non-thesis Masters students.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Loring Nies	Other agencies (including NSF) to which this proposal has

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:
Response of Aquatic and Terrestrial Microorganisms to Carbon-Based Manufactured Nanoparticles

Source of Support: National Science Foundation
Total Award Amount: $1,600,000 Total Award Period Covered: July 2004 – June 2009
Location of Project: Purdue University
Person-Months Per Year Committed to the Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:
Biotransformation Potential of Commercial Model Fluorotelomers in Soils

Source of Support: National Science Foundation
Total Award Amount: $349,960 Total Award Period Covered: July 2006 – June 2009
Location of Project: Purdue University
Person-Months Per Year Committed to the Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:
Assessing the Impact of Functionalized Single-Wall Nanotubes on Anaerobic Microbial Communities

Source of Support: National Science Foundation
Total Award Amount: $100,000 Total Award Period Covered: July 2008 – June 2011
Location of Project: Purdue University
Person-Months Per Year Committed to the Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Cal: Acad: Sumr: