

Sustainable Products & Solutions Program

2011-2012 Annual Report



CENTER FOR
**RESPONSIBLE
BUSINESS**

Haas School of Business at UC Berkeley

About

The mission of the Sustainable Products & Solutions (SPS) Program is to establish a diverse research community dedicated to finding new, innovative ways to integrate sustainability into products and business. To achieve this, it focuses on projects and programs that take a multi-disciplinary approach to research and learning.

Since 2008, the SPS Program has been funding research, teaching, fellowships, competitions and symposiums that seek sustainable solutions to global challenges. The program is based in the Center for Responsible Business in the Haas School of Business at the University of California, Berkeley.

Berkeley-Haas and the College of Chemistry developed the SPS Program with a five-year, multi-million dollar commitment from The Dow Chemical Company Foundation. In 2010, Kimberly-Clark and Waste Management joined to support research in the area of sustainable end-of-life management for consumer products.

With topics ranging from carbon foot-printing and green chemistry to safe drinking water solutions, the projects the SPS Program supports build on UC Berkeley's tradition of excellence in sustainability research and teaching.

Supporters



Cover: Faculty and students from eight universities worldwide, Dow representatives, and Center for Responsible Business staff visiting the Dow Wetlands Preserve during the 2011 Dow Sustainability Innovation Student Challenge Conference

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Introduction

The 2011-2012 academic year marked the fourth year of the Sustainable Products & Solutions (SPS) Program. Through its diverse portfolio of funded research projects, courses, and special events, the SPS Program continues to encourage progress in sustainability research and education.

The successes of this year's research grantees includes developments such as the pilot launch of a low-cost groundwater arsenic filtration system in West Bengal, India to the development of a safer oil dispersant that can be deployed for clean-up in the case of future oil spill disasters. Many of these projects are ongoing and we look forward to further progress updates from the research teams.

In 2010, SPS began a new research track focused on end-of-life management for consumer products, sponsored by Waste Management and Kimberly-Clark. We are continuing to see the results of the initial dozen projects that were supported through that initiative this year. They involved a wide variety of participants, from UC Berkeley researchers to students to Waste Management and Kimberly-Clark employees.

The SPS Program also made possible several interdisciplinary courses on topics related to sustainability, offered by the Haas School of Business, Department of Chemistry, and Department of Earth and Planetary Science. It supported large, multi-stakeholder events such as the Roundtable on Electronic Supply Chain Social Impact Assessment, 19th CIRP Conference on Life Cycle Engineering, and 2011 Dow Sustainability Innovation Student Challenge Award Conference; for these events, UC Berkeley welcomed hundreds of proponents of sustainable products and solutions from across an array of industries and sectors.

As always we are deeply grateful to **The Dow Chemical Company Foundation, Kimberly-Clark and Waste Management** for their generous support. Their intellectual and financial contributions are both significant and meaningful for the researchers, students and other stakeholders involved in the Program.

For the year ahead, we plan to engage even more faculty and student teams at UC Berkeley on leading-edge interdisciplinary sustainability research and other activities as well as build awareness of the SPS Program throughout the campus and in the world at large.



Jo Mackness
Executive Director
Center for Responsible Business



Tony Kingsbury
Executive-in-Residence (2008-2012)
Sustainable Products & Solutions Program

Sustainability Research



Eco-System Services

Helping companies determine how to take into account the value of the natural world and how to value externalities in terms of both business risks and opportunities



Project: *Moving Biomass Chemicals to the Market*

Principal Investigator: Prof. Alastair Iles (Environmental Science, Policy and Management)

During much of the last century, the chemical industry flourished in utilizing petroleum as its primary feedstock. In recent years, however, the preeminence of petrochemicals has been less certain as oil prices have increased and become more volatile, and as concerns over environmental impacts have increasingly influenced corporate decision-making. The use of bio-based chemicals (BBCs) has emerged as an attractive alternative, yet they face technical and strategic challenges to entering the market.



This project examines the emerging industrial landscape of BBC production, focusing on whether and how companies are evaluating the environmental and social impacts of their chemicals, and how government and industrial policies can help accelerate the progress of these chemicals to the market. The team's research indicates multiple factors that affect the introduction of biomass chemicals to broader markets. These factors include poorly coordinated government policies, market and technological uncertainties, challenges in sourcing feedstock, and lack of integration of

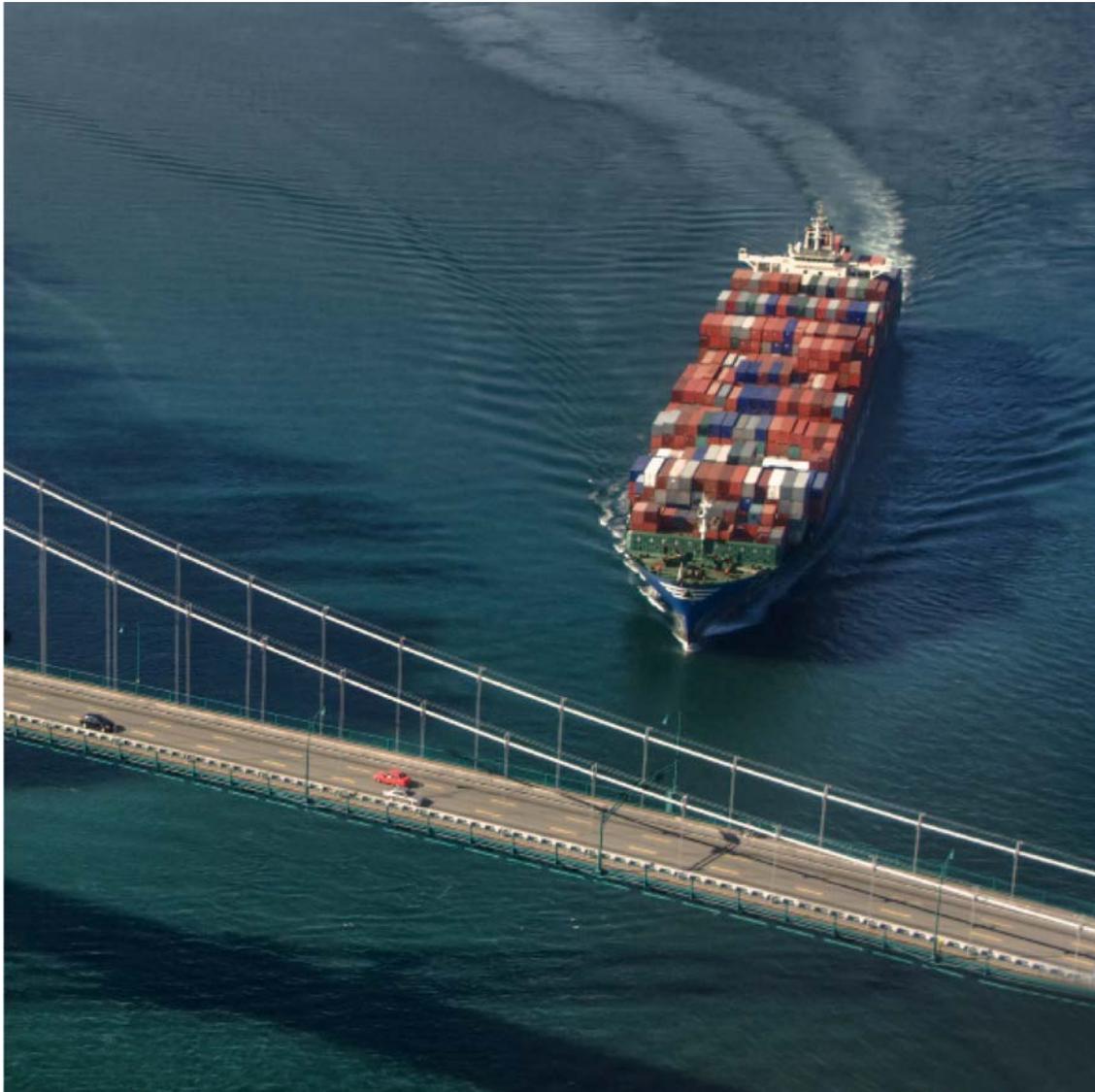
environmental issues into the design of BBCs.

The SPS-funded research team has two manuscripts slated to be completed by the end of 2012; the first will share findings on the extant process of sustainable innovation as seen through the emerging BBC system and identify the next steps needed for the policy community and scholars of sustainable innovation. It takes the assumption, a priori, that a transition towards BBC production brings societal benefit.

A second companion paper examines this assumption more critically and is aimed at the business and policy community more broadly. A transition to BBCs would be expected to diminish impacts associated with the petrochemical system, for instance, but would introduce new environmental, social, market, and industry impacts, both anticipated and unanticipated. Key questions include: how are these risks, uncertainties, and ethical concerns incorporated into public discourse and public decision-making? What are the specific tools and approaches being used or considered? Considering these questions from a business perspective is necessary to forestall unfounded public fear about the sustainability of BBCs and mitigate risks that could threaten the longer-term viability of BBCs.

Sustainable Supply Chain Management

Taking a systems approach to product and solution development, to help companies make their supply chains more sustainable



Project: *Towards Sustainable Supply Chains: A Multidisciplinary Approach for Corporations and Policy Makers*

Principal Investigator: Prof. Omar Romero-Hernandez (Haas School of Business)

Improving the sustainability and performance of products and services is at the core of innovation and competitive advantage. One of the many motivations for improving the sustainability of a firm's supply chain is the fact that external stakeholders do not usually distinguish between a company and its suppliers. Tackling this problem is not trivial; there are many activities in a supply chain with complex interactions and trade-offs.

This project builds on previous research work supported by the SPS Program and focuses on the sustainability implications of products along their entire supply chains. The work has addressed a set of sustainability criteria used for supplier selection, facilities location, and product manufacturing. This research effort has resulted in the development of assessment models, a Life Cycle Assessment (LCA) methodology, and a hypothetical case study on modeling the shipping of goods from Mexico to California.

In addition, the team has modeled a green supply chain system, analyzing the production and distribution of photovoltaic panels. This work was published in the Proceedings of the 19th CIRP Conference on Life Cycle Engineering and presented in the LCA XI Conference in Chicago in October 2011. It has also been adapted for the core of a new Berkeley-Haas Business Case Series and is available now from [California Management Review](#) under the title "Han Solar and the Green Supply Chain."

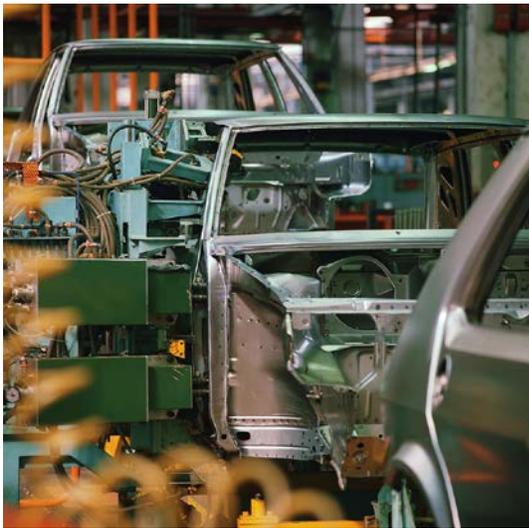


Prof. Romero-Hernandez delivering a talk

A second green supply chain regarding bioenergy in the United States and Mexico is also being studied. This work is being carried out jointly by the Haas School of Business, Goldman School of Public Policy, Instituto Tecnológico Autónomo de México (ITAM) and the Woodrow Wilson International Center for Scholars in Washington D.C. The research team expects to produce a publication in 2012.

Project: *Assessing the Social Impacts of Supply Chains*

Principal Investigators: Prof. David Dornfeld (Mechanical Engineering), Prof. Zuo-Jun “Max” Shen (Industrial Engineering and Operations Research), and Prof. Sara Beckman (Haas School of Business)



This research team focused on identifying and categorizing social impact metrics to be incorporated into decision-making tools for designers. Their research builds upon prior work to categorize Design for Environment (DfE) principles and metrics by their expected sustainability impact, and by the design and life cycle phases in which the principles could be best addressed.

Three prominent sources for metrics of social impact were compared to evaluate their effectiveness and comprehensiveness in addressing social responsibility, and to reveal gaps or subject areas that are not addressed:

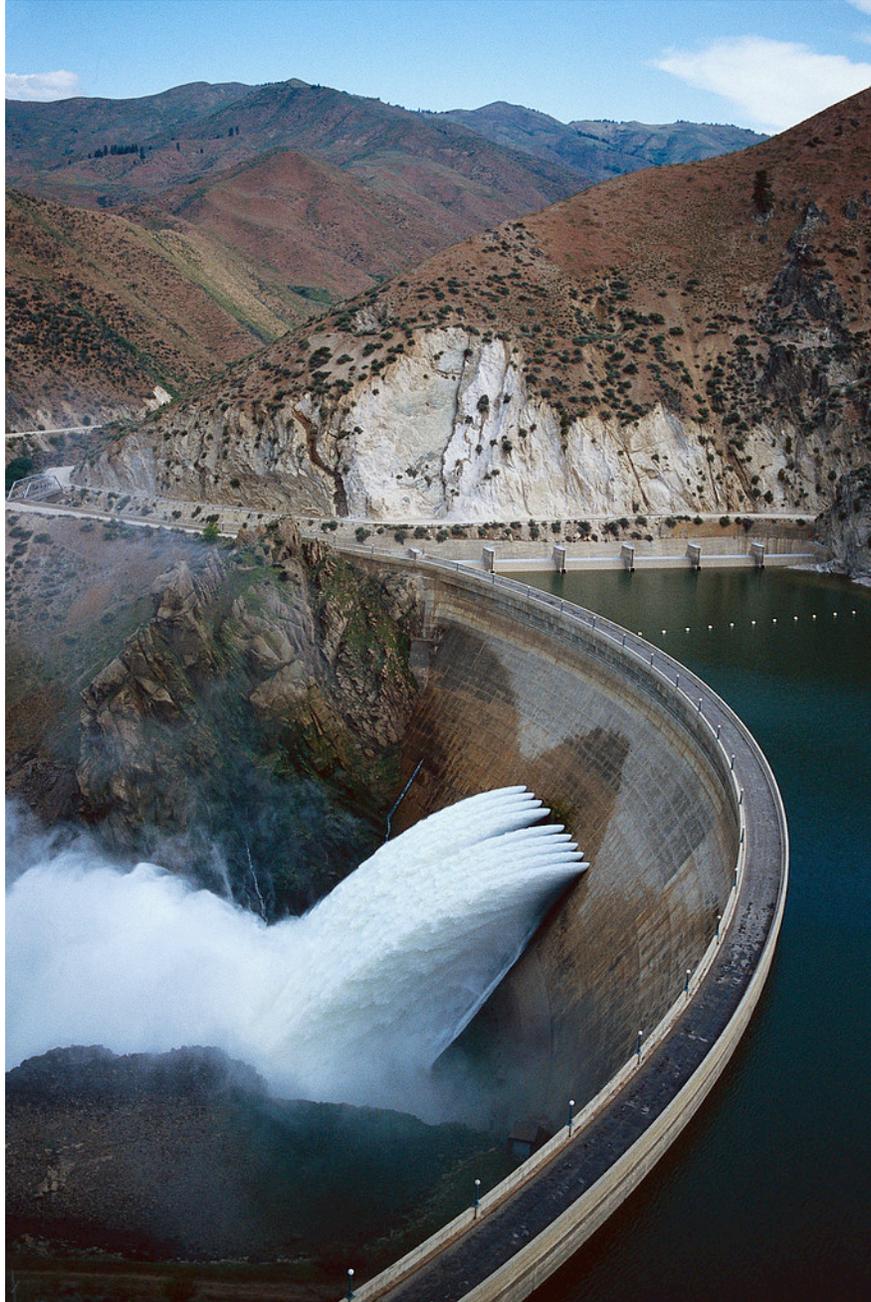
- International Organization for Standardization (ISO) 26000: Guidance on Social Responsibility (2010)
- Global Reporting Initiative (GRI): Sustainability Reporting Guidelines (2011)
- United Nations Environment Programme and the Society for Environmental Toxicology and Chemistry (UNEP-SETAC): Social Life Cycle Assessment Methodological Sheets (2010)

Although there is substantial overlap in the coverage of social impacts among these three documents, discrepancies were found in the coverage of several themes. For instance, it was discovered that ISO and UNEP-SETAC are focused on educating suppliers while GRI is focused on assessing suppliers. Additionally, many of the social impacts covered by ISO 26000 fall into the category of “business practices” and are not intuitively translated into design principles.

It is necessary to better understand the relationship between social guidelines and DfE principles so that social indicators can be mapped to design. Future work for this project includes analyzing characteristics of guidelines that are useful in design and/or manufacturing and assembly, as well as the characteristics of principles in the DfE framework compared to those in ISO 26000.

Sustainable Resource Management

Developing products and solutions to better manage the world's natural resources and promote more sustainable consumption



Project: *Integrating Chemistry and Toxicology for the Design of Inherently Safer Oil Dispersants*

Principal Investigators: Prof. Chris Vulpe (Nutritional Science and Toxicology), Prof. John Arnold (Chemistry), and Dr. Martin Mulvihill (Center for Occupational and Environmental Health)

In the wake of the Deepwater Horizon oil spill, more than 2 million gallons of oil dispersant were used in the Gulf of Mexico. After the dispersants had been implemented in unprecedented volumes, it was recognized that there was little or no toxicity information on these products.

The recent use of these oil dispersants and the later studies revealing their toxicity has highlighted the need to develop

alternative less toxic dispersants. This project proposed to develop and test inherently safer oil dispersants by applying the principles of Green Chemistry in tandem with toxicity screening.

The team has made significant progress during its first year of support from SPS toward the validation of the tandem toxicology green molecular design approach. A review of oil treatment techniques has been submitted to *Environmental Health Perspectives* and is currently under review.

In addition to the research progress, the funding has supported students and developed new collaborations on and off campus. In particular, the team has been partnering with microbiologists at Columbia, Tulane, and UC Berkeley to study the mixture of naturally produced rhamnolipid surfactants, and evaluate the potential to mimic biosynthetic pathways.



“This pilot project has proven the potential benefits of interdisciplinary partnerships between toxicology and chemistry, and has increased collaboration with the biological sciences.”

— Prof. Vulpe, Prof. Arnold, and Dr. Mulvihill commenting on their collaboration

The project has also led to many interdisciplinary partnerships. For instance, the success of this pilot project has encouraged the principal investigators to pursue the development of a Center for Sustainable Synthesis as a partnership between the Chemistry and the Toxicology departments. Initial proposals have garnered support from the Dean of Chemistry, Rich Mathies, and the Berkeley Institute of the Environment Director, Martyn Smith.

World Challenge Solutions

Taking scalable, market-based approaches to solve the world's most pressing social issues, including water, health, food and housing



Project: *Clearing Arsenic from Drinking Water for 60M Bangladeshis and Indians: Demonstrating a Scalable Model*

Principal Investigators: Prof. Ashok Gadgil and Dr. Susan Addy (Civil and Environmental Engineering and Lawrence Livermore National Laboratory), Prof. John Danner (Haas School of Business), Dr. Joyashree Roy (Jadavpur University)

Naturally occurring arsenic contamination has been discovered in groundwater in many countries. Bangladesh and India are the most affected, with over 60 million people exposed to dangerous arsenic levels substantially above the maximum contaminant level recommended by the World Health Organization. There is no cure or effective treatment for arsenic poisoning and the problem is expected to get worse unless access to arsenic-safe water increases. However, 20 years after the problem was discovered, no effective and affordable treatment technology has been implemented on a large scale.

In response to this need, the cross-disciplinary team is designing a water treatment system that utilizes Lawrence Berkeley National Laboratory (LBNL) technologies to effectively remove arsenic from drinking water. Additionally, the technology will be produced using a sustainable business model.



The team's two interns, Siva and Chris, in Mumbai working with a manufacturer to build an ECAR prototype

In the past year, the team has taken big steps toward bringing the technology to market. A 600L ElectroChemical Arsenic Remediation (ECAR) prototype was designed and manufactured in Mumbai in spring 2012 by two members of the team. The system was reassembled by the Civil Engineering Department at Jadavpur University in Kolkata. The team spent 1.5 months rigorously testing and improving the prototype. It now reduces arsenic levels below the WHO maximum recommended levels at very low cost.

On the business front, the international company Lafarge Cement is testing possible stabilization methods for the arsenic-laden sludge that is left over from the filtration process. An interested licensee from another large company visited the team's installation in Jadavpur, which further underscored the private sector's interest and provided feedback on how to make the water treatment technology more attractive and suited to industry needs.

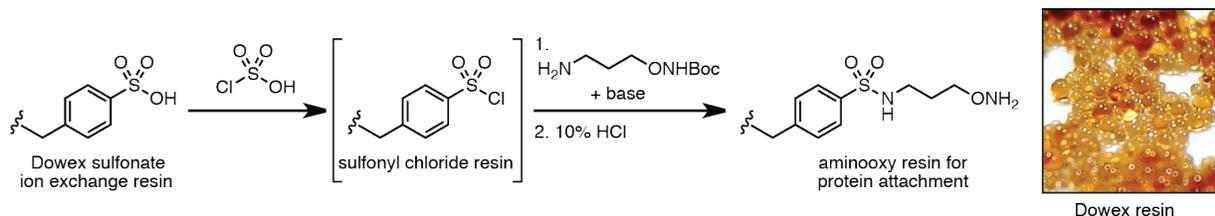
Looking ahead, the team started a four month trial period for the 600L prototype at a school near Kolkata in September. They will provide 1-2 L/day of arsenic-safe water to the schoolchildren and sell the excess capacity to the community to assess demand.

Project: Protein-Polymer Hydrogels for the Selective Detection and Removal of Heavy Metal Pollutants in Water

Principal Investigators: Prof. Matthew Francis (Chemistry) and Prof. Douglas Clark (Chemical and Biomolecular Engineering)

This research project aims to prepare hybrid biomolecular/polymeric materials that can remove toxic heavy metals from contaminated water. The outcome of the work will be a new set of inexpensive and readily scalable materials that can remove metal ions from industrial waste streams or contaminated water sources.

A key component of this study is the development of abundant, low-cost materials that allow the facile recovery of metal binding ligands to attach to their surfaces (see figure below). The team is now able to produce reusable water treatment materials with high mechanical stability and ligand loading rates. To the best of their knowledge, this is the first example of the attachment of biomolecules to these supports.



Method for the efficient functionalization of polystyrene resins for protein and peptoid attachment, which has allowed the team to produce inexpensive, reusable water treatment materials.

One of the advantages of macromolecular structures for binding heavy metal ions is their structural and functional adaptability through directed evolution. In their initial experiments, the team evaluated the toxicity levels of targeted heavy metals towards potential *E. coli* selection strains. They also generated mutant libraries of the reengineered nickel transcription factor NikR' for expression; the winner clone(s) will be evaluated for metal binding effectiveness.

The team has also developed an efficient strategy to identify a new class of inexpensive peptoid structures capable of binding to specific metal ions of interest. This strategy has already led to the identification of some of the first selective binders for highly-toxic Cr⁶⁺ ions.

In principle, this very powerful approach could be generalized for the identification of new binders for virtually any metal of interest.

Project: *Biomimicry: Using Nano-Engineered Enhanced Condensing Surfaces for Sustainable Fresh Water Technology*

Principal Investigators: Prof. Van P. Carey and Prof. Samuel S. Mao (Mechanical Engineering)

Condensation of water is an important process in nature and in technological applications. Successful strategies for promoting dropwise condensation of water can be particularly important to distillation technologies for desalinating or purifying water. Use of waste heat to facilitate distillation-based water purification will be increasingly attractive as worldwide demand for water increases.



A Namib Desert beetle

This research project, which was also funded by SPS in 2011-2012, uses biomimicry to find an innovative sustainable solution for this need. The the Namib Desert beetle's unique back features alternating hydrophobic-hydrophilic regions, aiding its survival in a water scarce desert environment. The research team investigated the feasibility for an enhanced water condensation technology by patterning a zinc oxide (ZnO) surface to mimic the beetle's back.

The team has successfully developed and implemented a scalable and practical technique to satisfy this main objective. Per the challenge to enhance condensation of water from a humid environment, they have been able to quantify dropwise condensation heat transfer coefficients in high air mass concentrations of 16-68%, compared to the available literature results of only 0.5-5%.

Given these findings, the researchers have identified a new, simplified fabrication technique that can promote patterned dropwise-filmwise condensation on a metal substrate. This new technique offers opportunities for enhancing condensation by incorporating it into existing condenser applications and developing new technologies.

To date, the team has had one of their conference papers accepted for the ASME (founded as American Society of Mechanical Engineers) 2011 International Mechanical Engineering Congress and Exposition (IMECE) as well as submitted to the *Journal of Heat Transfer* for review. More recently, another paper building from this research was accepted with an honors recommendation to ASME 2012 IMECE.

"Many thanks to the SPS Program for enabling us to explore an innovative, yet practical method for providing a more energy-efficient and sustainable method for fresh water collection. The support from the SPS Program has been instrumental to the success of this project, especially for ensuring we could investigate scalable and sustainable techniques."

— Sara Al-Beaini, Mechanical Engineering Ph.D., member of the research team

Carbon Management

Finding creative ways to economically capture and manage carbon, as the world seeks solutions to managing climate change potential



Project: Organometallic Frames for Sunlight Storage
Principal Investigators: Prof. Peter Vollhardt (Chemistry)

The direct conversion of solar photons for powering the planet is one of the most important scientific and technological challenges of this century. The bulk of intensive efforts to meet this challenge has been directed toward photoinduced generic charge separation, such as in photovoltaics, or solar fuel generation, such as in biofuels. Direct collection of heat from sunlight has received much less attention.

A relatively unexplored alternative is trapping solar energy in the form of chemical bonds through the photoconversion of a suitable molecule to a higher energy isomer. Such a system would constitute a rechargeable heat battery, with its inherent advantages of storage, transportability, and use on demand. However, a functioning device has yet to be developed due to limited stability and other difficulties.

This research team's solution is an organometallic molecular system that absorbs solar radiation, stores the energy through formation of high-energy isomers, and then catalytically releases the energy as heat when needed.

The team has completed construction for a solar-thermal device; optimization of the energy conversion and release processes is being completed and a publication is in preparation. In a combined study involving discrete fourier transform calculations of the excited state, they have also pinpointed the details of the light harvesting step of the process. A publication is in preparation for this as well.

The other work the researchers have engaged in includes:

- Probing the relationship between structure and the enthalpy of solar storage
- Exploring cheaper and more environmentally agreeable alternatives to ruthenium for the system, in conjunction with designed ligand modifications
- Bringing a new visiting scholar (funded by the China Scholarship Council), who is an expert in surface techniques and will establish the nature of the catalyst for the thermal reversal as well as improve turnover numbers
- Partnering with the Cleantech to Market program at the Berkeley-Haas to assess the viability of this system as a commercial venture



An article on alternative energy highlighting the team's work in the June 2011 issue of Popular Mechanics

Teaching



Course: CHEM298 Green Chemistry and Sustainable Design Seminar Series

Organizer: Berkeley Center for Green Chemistry (BCGC), Berkeley Institute of the Environment

“What makes a chemical safe and sustainable? How do we improve our chemical methods to address issues of waste, energy consumption, and safety? And what roles do those from academia, industry, and public policy take in achieving these initiatives? We believe solving these problems represents a tremendous opportunity to develop new chemistries through both focused research and interdisciplinary collaboration.”

— Overview from the seminar series syllabus

The Green Chemistry and Sustainable Design Seminar hosts high impact lectures to elucidate the importance, current state, and applicability of green chemistry. They are primarily aimed at a chemistry-based audience, but the topics covered range widely to appeal to an interdisciplinary audience. The fall 2012 lecturers came from both academia and industry to provide a diverse range of viewpoints:

- Prof. Louis J. Guillet, from the Medical University of South Carolina and a Howard Hughes Medical Institute investigator, examined the detrimental effects of chemical byproduct buildup on reproductive and developmental endocrine systems.
- Professor Chao-Jun Li from McGill University, the recipient of the individual 2010 Canadian Green Chemistry and Engineering Award, presented his work on performing atom-economical chemistry in environmentally safe solvents.
- Dr. Adelina Voutchkova, now an assistant professor at George Washington University, introduced her progress toward the rational design of safer industrial chemicals.
- Dr. Joseph Armstrong, Senior Director of Process Research at Merck & Co. and the leader of the team that received the Presidential Green Chemistry Challenge Award in 2006, showed how green chemistry is practiced in an industrial setting.
- Prof. Bruce Lipshutz from the University of California, Santa Barbara, the 2011 recipient of the Presidential Green Chemistry Challenge Award, presented his group’s work toward performing organometallic reactions at high concentrations in water.
- Helen Holder, the Corporate Materials Selection Manager at Hewlett-Packard, described the central role green chemistry has within the vetting process of the materials fit for long-term industrial use in HP products.

Overall, the series provided a broad overview of the rationale behind green chemistry, a glimpse into some of the tools currently available to perform green chemistry, and an introduction to the business implications of implementing green chemistry tenets.

Course: MBA292T.5A Driving Sustainability Through Business
Instructors: Tony Kingsbury and Jo Mackness (Haas School of Business)

The objective of this new survey course, which enrolled 25 students in its first year, was to show how sustainability could be integrated throughout and drive all areas of business operations, including finance, marketing, product design/innovation, human resources, operations/supply chain, new business development, and strategy.



One of the course instructors for MBA292T.5A, Jo Mackness

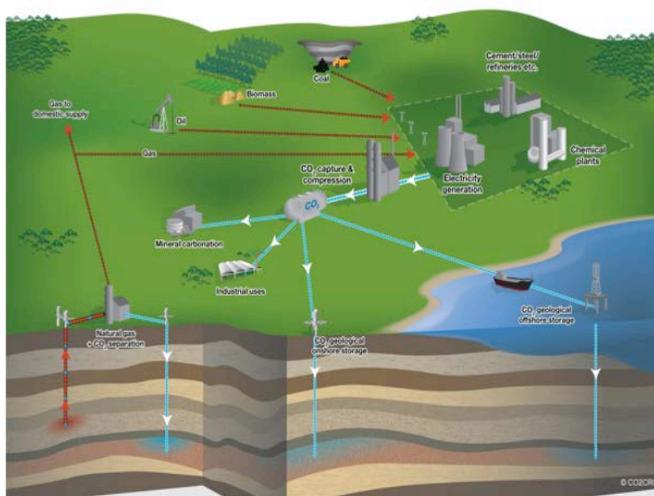
Each week focused on a different functional area and explored how an individual or a team within that functional area can use a sustainability perspective to mitigate risk, drive strategy, identify new business opportunities, and differentiate oneself in terms of career development.

The course used a variety of teaching methods including case studies, group projects, readings, class presentations and guest lecturers (including leading practitioner experts within the business community). Students finished the course with strengthened strategies and skills to make sustainability a part of their careers regardless of their job role or function.

Course: C195P/C295Z/C236: The Berkeley Lectures on Energy: Carbon Capture & Sequestration

Instructors: Prof. Berend Smit (Chemical and Biomolecular Engineering, and Chemistry), Prof. Jeffrey Reimer (Chemical and Biomolecular Engineering), Prof. Jeffrey Long (Chemistry), Dr. Curt Oldenburg (Lawrence Berkeley National Laboratory), Dr. Ian Bourg (Lawrence Berkeley National Laboratory)

Sustainable energy generation is seen as one of the largest challenges of our generation. All long-term solutions rely heavily on the conversion of solar energy, yet these solutions appear to be years from implementation. In the coming decades, while the relative importance of fossil fuels will decrease, absolute use of fossil fuels will not. Carbon Capture and Sequestration (CCS) employed on a global scale can sustain the world's energy use and help mitigate alarmingly high CO₂ levels in the atmosphere.



A system of carbon capture and sequestration

UC Berkeley and Lawrence Berkeley National Laboratory have large research programs addressing Carbon Capture and Sequestration. The Berkeley Energy Lectures aimed to introduce these research programs to undergraduate and graduate students in the Sciences and Engineering. Topics included current understanding of CO₂ in and around the planet, the geological storage of CO₂, and the science and technology of carbon capture.

The lectures were open to all upper division undergraduates in the Sciences and Engineering with sufficient background in Chemistry, Physics, and Mathematics. At the end of the series, students had state of the art knowledge of the science related to CCS and were able to work in multidisciplinary teams to compare different CCS solutions.

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“I thought it was interesting to see the different conclusions various speakers drew from their personal research. They didn't always agree, and that gave a more comprehensive view of carbon capture and sequestration.”

— Feedback from a student in the course

Consumer Products: Sustainable End-of-Life Management



Current Projects

Project: Social and Political Issues Surrounding Municipal Solid Waste Conversion Technology Adoption

Principal Investigator: Prof. Omar Romero-Hernandez (Haas School of Business)

This project explores the reasoning behind and relative influences of factors contributing to the opposition to installations of Municipal Solid Waste (MSW) conversion technologies. It includes case analyses and surveys/interviews with opposing groups, policy makers and companies. The study seeks to identify MSW conversion opponents, clarify MSW conversion opposition positions, and find why some MSW conversion facilities were implemented and some were not.

The first phase of a literature review has been started. Preliminary findings show that MSW conversion technologies of pyrolysis and gasification are, in general, believed to have larger benefits than other MSW conversion technologies. However, due to the lack of general knowledge about pyrolysis and gasification, the public may be tempted to examine the technologies through past experiences with solid waste incinerator technologies.

The project team also designed and distributed an electronic survey in order to gain an initial sense of official positions. The survey was sent to 24 nationally-focused organizations. Of the six who have filled out the survey, only one respondent organization had an official position regarding MSW conversion facilities, stating a generally favorable view.

Currently, the team is finalizing a set of potential phone interviews with thought leaders across the country. The aim of this set of activities is to gain a holistic understanding of the social and political issues surrounding MSW conversion technologies. The interviews will capture the views of regulators, private companies, lobbyist and NGOs.



Project: *A Tool for Business Opportunities in the Waste Management Sector*
Principal Investigator: Prof. Omar Romero-Hernandez (Haas School of Business)

This study aims to identify business opportunities in the waste management industry, particularly waste-to-energy or feedstocks, and develop a tool for multidimensional analysis. The output will be a business decision framework in which information on technology maps, feedstock profiles, and urban centers is integrated within a large multidimensional system.



The project assumes that large consortiums are frequently working in the operation of the waste management process, while small- to medium-size companies perform a significant portion of the R&D in technologies development. When a technology or company appears attractive, the consortiums will often approach and subsequently invest in or acquire the small companies and their technology. Both sides can benefit from these acquisitions and join collaborations.

Chances for success increase if the decision-making process includes a better understanding of the most promising geographical spots, technology trends, “sweet spot” for capacity size, and feedstocks.

The research team has gathered and analyzed white papers and industry background data as the first step toward technology characterization. They are also using an extensive database covering main waste generators and treatment facilities as well as U.S. maps detailing Municipal Solid Waste (MSW) exports and imports across states.

The entire continental U.S. has been disaggregated in order to understand dynamics across states and counties. Currently the team is working out a framework to be applied at the state/county level, using the state of California and its interactions (export and import of MSW) with neighboring states as a pilot.

The main products of this project will be a tool for business and technology scenario management and a research publication stressing methodology and opportunities for value creation.

Completed Projects

Project: Are All Life Cycle Assessment (LCA) Software Created Equal? How Design Tool Choices Influence Decision-Making and the Future of Sustainable Packaging

Principal Investigator: Prof. David Dornfeld (Mechanical Engineering)

The ability to accurately assess the sustainability impacts of products and processes is critical for today's manufacturers, who are constantly adapting to rapidly changing regulations and consumer demands. While there are numerous tools currently available to conduct both general life cycle assessments and packaging specific evaluations, it is not clear if all can help users make better, more informed decisions about the sustainability of their choices.

This study, conducted in early 2012, compares a set of life cycle assessment (LCA) software tools in the context of packaging evaluations. Five software tools were evaluated from the perspective of the product manufacturer: Compass, GaBi, SimaPro, Sustainable Minds, and the Walmart Packaging Scorecard. 19 different packaging systems were evaluated in each of the various software tools.

The results indicated that each tool has its own advantages and opportunities for improvement, from either a methodological or usability standpoint. The choice between these categories of tools comes down to a tradeoff between ease and accuracy. Each of the tools also adopts its own inherent assumptions regarding composite materials, the end of life treatment of materials, and biogenic resource use and emissions.



This work only begins to illustrate the differences between LCA tools and practices. While the case studies were sufficient to show that such differences exist, the small sample size also prevented making further generalizations about the tools and means to achieving more sustainable packaging. Future work could further support the differences between packaging and assessment software options that have been touched upon in this study.

Project: *Paper Towel Reclaim in Costa Rica*

Principal Investigators: Berkeley-Haas MBA consulting team



One challenge for a company such as Kimberly-Clark (K-C) is the post-consumer waste created by the disposal of its products. For many reasons, including cost, raw materials management, sustainability, and responsibility, K-C is seeking ways to “close the loop” on materials. That is, how can K-C profitably use increasing amounts of post-consumer reclaimed materials as raw material inputs, as well as find innovative solutions to its products’ end-of-life disposal challenges?

The Berkeley-Haas MBA student team explored options for Kimberly-Clark Professional (K-CP) to work with its business clients to reclaim hand paper towels, defined as paper towels in public, businesses, or any facility restroom not in the home.

K-CP is running a pilot Paper Towel Reclaim Program in Costa Rica. The student team evaluated and analyzed this pilot to understand the operational and cost structure of paper towel reclaim. Based on this understanding, they made recommendations for how to expand paper towel reclaim programs throughout the Latin America region. The recommendations for expansion highlighted the value proposition that should be communicated to various stakeholders.

The team ultimately produced three main deliverables to assist K-CP in taking a significant step forward in its understanding of challenges and opportunities for paper towel reclaim, which were:

1. Financial Considerations for Costa Rica Paper Towel Program
2. Market-sizing for Paper Towel Reclaim Program Expansion
3. Stakeholder Field Guide

Project: *Global Sustainability Marketing for “Reduce Today, Respect Tomorrow”*

Principal Investigators: Berkeley-Haas Undergraduate consulting team

The well-received sustainability strategy and messaging platform, Reduce Today, Respect Tomorrow (“RTRT”) was launched in 2009 and focuses on a full product life cycle approach. As Kimberly-Clark Professional (K-CP) looked to the end of 2011 and into 2012, it had several innovations in the pipeline to support its RTRT platform and approach. This project focused on two key questions:

1. On what basis do different global customer segments make purchasing decisions and can K-CP leverage its sustainability messaging or product/solution design to influence those decisions?
2. How have other innovative, mainstream companies successfully used sustainability as a critical component of increasing profitability and/or company value, in markets and product segments where cost is often a primary purchase consideration?

The undergraduate team conducted detailed research on how sustainability leaders have convinced mass-market consumers to buy their product, focusing on how K-CP can target a mainstream market that typically may not be captured by overt green messages. They presented their deliverables to K-CP managers in November/December 2011.

Event: *Consumer Decision Making Workshops*

Leader: Prof. Eduardo Andrade (Haas School of Business)

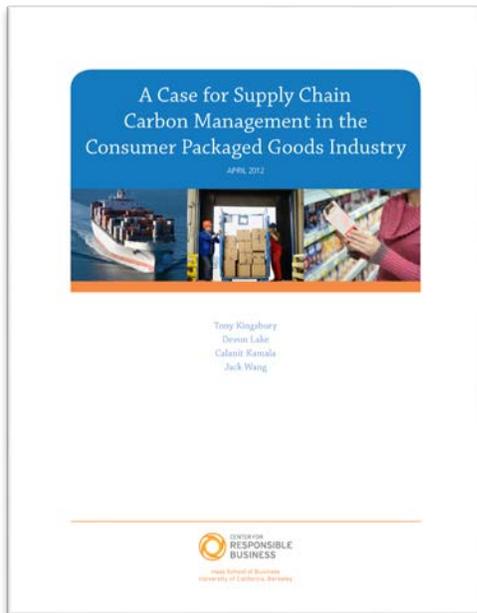


Prof. Eduardo Andrade

Prof. Andrade, a marketing professor who is an expert in the study of consumer decision-making behavior, presented a workshop at Kimberly-Clark’s headquarters in April 2011 and at Waste Management’s headquarters in September 2011. After explaining the advantages of designing field studies to better understand consumer behavior, he led employees in an exercise to help identify potential areas of research interest. Specifically, Prof. Andrade highlighted four broad categories where interventions can be made to promote behavioral change: informational, social, physical, and incentive-based. He then encouraged the audience to present areas in their respective contexts in which these variables could be manipulated in order to improve consumer and societal welfare.

Project: *Scope 3 Emissions Reductions Strategy Study*

Principal Investigators: Tony Kingsbury (Haas School of Business), Devon Lake (Haas School of Business), Jack Wang (Chemical Engineering), Calanit Kamala (International & Area Studies Program)



Targeting Scope 3 emissions is becoming the new frontier of carbon management, with certain consumer packaged goods (CPG) companies emerging as new environmental leaders in addressing climate change. This research documented the actions of some of these leaders as illustrations of cutting-edge practices for addressing Scope 3 emissions.

The final report for this project was published by the Center for Responsible Business in April 2012 under the title “A Case for Supply Chain Carbon Management in the Consumer Packaged Goods Industry.”

The report presented general approaches to measuring and managing Scope 3 emissions, providing companies with a road map for engaging with this work as well as specific recommendations for the CPG industry. It outlined

ways in which managing Scope 3 emissions creates competitive advantage, in the form of mitigating risks, decreasing costs, differentiation and increasing top line growth, strengthening the business rationale for Scope 3 management.

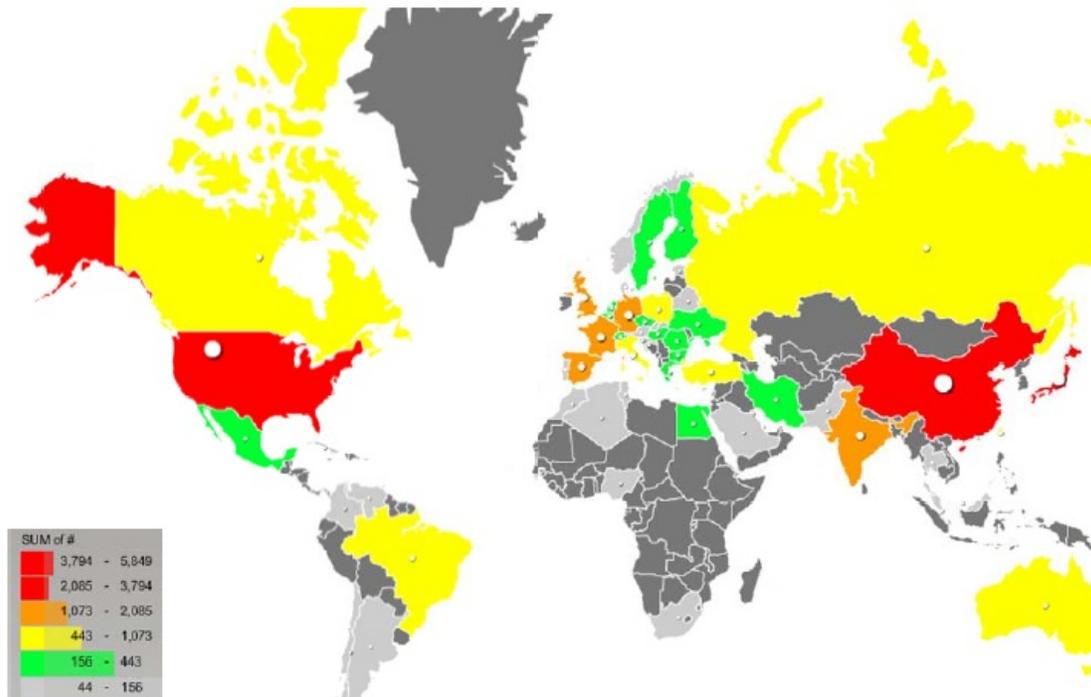
The report also made recommendations regarding the following items:

- Types of climate change strategies emerging from leading companies/industries
- Development of cost-effective, comprehensive Scope 3 emissions estimates. Estimates addressed elements such as supply-chain, capital goods, employee commuting, product delivery, product use and product disposal.
- Importance of product carbon footprints in an overall climate change strategy and leading practices for integration of carbon footprint information into overall company strategy.

Project: *Business Intelligence and Technology Trends Applied into the Waste Management Sector*

Principal Investigator: Prof. Omar Romero-Hernandez (Haas School of Business)

This project used technology maps as a means to understand technology trends and identify opportunities to create value through waste management practices. The study initially focused on a technology analysis for pyrolysis. In order to provide a more comprehensive view of conversion technologies, the analysis expanded into another set of conversion technologies, gasification.



Map generated by the researcher of the world distribution of scientific research in the field of pyrolysis, revealing that China, USA and Japan lead the way with almost 40% of all research publications..

These maps were mostly based on an extensive database search of scientific-technical publications, supported with public information on commercial reports and news. Results included time trends, research centers, controlled vocabulary, leading authors and, affiliations. Databases were cross-referred in order to understand potential feedstock-product pairs with the largest chances for business success. Commercial opportunities and barriers were identified, along with environmental implications and opportunities for further research.

The final report and presentation for this project were delivered in August 2011.

Stakeholder Engagement



Event: Roundtable on Electronic Supply Chain Social Impact Assessment

Date: January 31-February 1, 2012

The SPS Program's relationship with The Sustainability Consortium (TSC) has created a platform to engage stakeholders across a variety of industries. TSC is an organization of diverse global participants working to make the world more sustainable through better products, services and consumption.

In the past, the SPS Program and TSC have collaborated to host stakeholder roundtables on cotton and water, sustainable packaging, extended producer responsibility. This year, it was the Roundtable on Electronic Supply Chain Social Impact Assessment held on January 31 and February 1, 2012.



Participants engage in discussion during one of the roundtable seminars

54 participants, representing leading organizations in business, academia, and the nonprofit sector, attended the roundtable. The conference aimed to identify and address key social performance metrics in the electronics industry, as well as establish research needs associated with social risks and impacts. With so many experts from the field gathered, value came not only from the presentations, but also from informal conversations between attendees. Thus, the event included both talks and interactive discussions.

Among the many sessions were:

- An exercise identifying trends in social and environmental performance and metrics, led by Sara Beckman (professor at the Haas School of Business) and David Dornfeld (professor in UC Berkeley's School of Mechanical Engineering)
- A presentation on how TSC is helping electronics companies transform their metrics and reporting to drive innovation in their supply chains and enable product impact to be easily measured and communicated, given by keynote speaker Bonnie Nixon (TSC)
- A case study of the electronics sector's impact on the Democratic Republic of the Congo from demand for conflict minerals, presented by Patricia Jurewicz (Responsible Sourcing Network, a project of As You Sow)

To conclude the Roundtable, Tony Kingsbury, Executive-in-Residence for the SPS Program, led a closing discussion on potential collaborative opportunities and future avenues of research.

Event: 19th CIRP Conference on Life Cycle Engineering

Date: May 23 – 25, 2012



The 19th CIRP Conference on Life Cycle Engineering was held at UC Berkeley May 23 – 25, 2012. It was funded in part by the SPS Program, hosted by the Department of Mechanical Engineering, and organized by CIRP (College International pour la Recherche en Productique, or the International Academy for Production Engineering), an international organization founded to address issues related to modern production science and technology, scientifically and through international cooperation.

The theme of the 19th conference was “Leveraging Technology for a Sustainable World.” 174 participants from 26 countries attended, partaking in enriching sessions on topics such as Life Cycle Design, Manufacturing Systems, and Methods and Tools for Sustainability.

The conference spurred interdisciplinary discussions between cross-sector participants, including those from industrial companies represented by seven sponsors. The keynote speakers were:

- Julian Allwood, University of Cambridge (Opening Ceremony)
- Rich Helling, Dow Chemical (Opening Ceremony)
- Adam Hansel, DTL – DMG / Mori Seiki USA
- Michael Overcash, Wichita State University
- Karen Huber, Caterpillar, Inc.

The scientific contributions were of high quality due to the thorough review and large number of competing contributions. More abstracts and papers were submitted compared to last year’s LCE conference. Hao Zhang and his advisor Dr. Karl Haapala of Oregon State University received the 2nd Annual LEO Best Paper Award for their submission, entitled, "Integrating Sustainability Assessment into Manufacturing Decision Making."

Event: 2011 Dow Sustainability Innovation Student Challenge Award (SISCA) Conference

Date: October 4-5, 2011

The Dow Chemical Company recognized the winners of its third annual Sustainability Innovation Student Challenge program at a two day event hosted by UC Berkeley on October 4-5, 2011. 37 students and faculty from eight universities located around the world came to be recognized for their innovation and commitment to providing sustainable solutions to the world's most pressing social, economic, and environmental problems.

Award winners were selected using a peer review process by the participating universities, with guidance and criteria provided by Dow. A total of 46 winners were recognized globally for their enthusiasm and commitment to sustainability. Each winning team received \$10,000.



Ursina Kohler and Jarod Davis, both from Dow, at the poster session on day two of the conference

The first day of the program included a trip to Pittsburg, CA (just north of Berkeley) for a tour of the Dow Wetlands Preserve. The afternoon session included a panel discussion on Trends in Sustainability and a Technology Transfer Workshop, both led by sustainability business and academic leaders. The second day of the program included a Bay Area Green Tour, Eco-System Services Panel Discussion, and poster session.

Dr. Neil Hawkins, Vice President, EH&S & Sustainability, The Dow Chemical Company spoke at the event. The keynote address was delivered by Dr. Jay Keasling who is a professor in the Department of Chemical & Biomolecular Engineering at UC Berkeley, Senior Faculty Scientist and Director of the Physical Biosciences Division at the Lawrence Berkeley National Laboratory, Director of the Berkeley Center for Synthetic Biology, and Chief Executive Officer of the Joint Bioenergy Institute.

Closing Remarks

Our Gratitude

As always, we thank The Dow Chemical Company Foundation, Kimberly-Clark and Waste Management for their continued generous support of the SPS Program. We are deeply grateful for their partnership.

Farewells and Welcomes

After a 5 year stint as the Dow Executive-In-Residence at the Center for Responsible Business, Tony Kingsbury has retired from Dow and thus from his post leading the SPS Program. We are truly grateful to him for his dedication to SPS and wish him well in his future endeavors.

The SPS Program continues with Dow, Kimberly Clark and Waste Management's support and under new leadership. Professor Omar Romero-Hernandez will take on key elements of Tony's role as the new SPS Senior Research Advisor.

Omar is a Chemical Engineer with graduate studies in Economic Policy and Government and a PhD in Process Economics and Environmental Impact from Imperial College, London, UK. In addition to his SPS responsibilities, he is a faculty member and professional researcher associated with the Center for Responsible Business.

Omar has worked internationally for a diverse range of public and private organizations such as Procter & Gamble, PEMEX (Oil & Gas), Accenture, and the Ministry for the Environment and Natural Resources. In 2001, he was appointed as Professor at the Autonomous Technology Institute of Mexico (ITAM), and in 2009 he was appointed by a National Committee as Fulbright Visiting Professor-Researcher at UC Berkeley.



Currently, he is a National Researcher, recognized for his applied research achievements. He has authored three books: [Renewable Energy Technologies and Policies](#), [Industry and the Environment](#), and [Introduction to Engineering—An Industry Perspective](#). He has also written several international publications on engineering, business and sustainable development. Omar has led various internationally awarded research projects in the field of renewable energy, sustainable business strategies, the stock exchange, and business processes; sponsors include the United Nations, Ministry of the Environment, S&P 100 companies, and NGOs.

Omar was the former Director of the Center for Technological Development (CDT) at ITAM. In 2010 he was appointed by the former President as national leader of Mexico's Business Summit task force on Economic Growth and Low Carbon Emissions. He is the recipient of the 2010 Franz Edelman Award, the world's most prestigious award for Operations Research and Management Science.

We welcome your feedback!

Send us your comments regarding this Sustainable Products & Solutions Program Annual Report and let us know what you would like to see us address in future reports.

You can also keep updated with SPS Program opportunities and projects throughout the year by visiting our website and emailing us with your questions.

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