



AIChE Sustainable Engineering Forum Newsletter

Vol. 2 No. 1

March 2008

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SEF Website:
http://webpages.eng.wayne.edu/~as8971/AIChE_SEF/



MESSAGE FROM CHAIR

I would like to begin by welcoming all of our members to a new year and new leadership for the Sustainable Engineering Forum. Our leadership consists of a strong team of academic and industrial leaders eager to build on the momentum that our predecessors have created.

Due to the commitment of past leadership and the strong support from the Institute for Sustainability (IfS), the SEF has been able to achieve many accomplishments over the past two years. One of the main areas of growth for the SEF is in programming. Including sponsored and co-sponsored activities, our participation at the AIChE Spring and Annual Meetings has consistently continued to increase. This year is no exception, as we have many interesting sessions scheduled for both the upcoming Spring and Annual meetings, which are discussed later in the newsletter.

Other areas of SEF growth over the past years have been in membership, and participation in outreach efforts and international networking through joint topical and international conferences. A great deal of gratitude and appreciation must also be given to Earl Beaver for his tireless efforts in organizing virtual meetings, which cover a broad spectrum of sustainability topics. An additional area of growth has been in the creation of the SEF newsletter. Building on the success of the newsletter last year, this year, the newly designed circular, which includes an updated format and the addition of an education column, will be distributed quarterly.

Furthermore, a great deal of effort has been devoted to the initiation of an award program and the creation of three technical areas, General, Sustainable Energy, and Sustainable Biorefineries, within the SEF. The purpose of the creation of these areas is to broaden our programming capabilities and promote research and networking in these specific areas of sustainable engineering.

The United Nations Educational, Scientific and Cultural Organization defined the Decade of Education for Sustainable Development (2005-2014). Its goal is to “integrate the principles, values, and practices of sustainable development into all aspects of education and learning.” As Chair, and with the help of our Education Committee Chair, Ralph Pike, I will work with the team to ensure the growth of the SEF’s educational programs.

Despite the numerous accomplishments achieved by our previous leadership, there is still a great deal of work to be done. I am confident that with this strong leadership team in place and having the knowledge and experience of past chairs, Subhas Sikdar and Martin Abraham, and the technical advisor, Mahmoud El-Halwagi, available to us, the SEF will continue to grow stronger over the years to come.

Yinlun Huang
Chair, Sustainable Engineering Forum

ANNOUNCEMENTS

AIChE 2008 Spring Meeting – SEF Programming

The AIChE 2008 Spring Meeting is quickly approaching, to be held April 6-10, 2008 in New Orleans, LA. SEF will sponsor a topical session, Sustainability: Lessons, Actions and Outlook (Topical 9), which is co-sponsored with ACS.

The full listing of SEF programming activities for the week is provided below.

Topical 9: Sustainability: Lessons, Actions and Outlook – Jointly Co-sponsored with ACS

Wednesday, April 9, 2008

2:00 PM-5:00 PM

#210 – Sustainable Feedstocks (T9005)

Thursday, April 10, 2008

8:30 AM-11:30 AM

#225 – Case Studies in Design for Sustainability (T9004)

Additional Programming Co-sponsored with ACS

Wednesday, April 9, 2008

2:00 PM-5:50 PM

#212 – Incentives and Barriers to the Adoption of Sustainable Chemistry (TA052)

6:00 PM-8:00 PM

#218 – Incentives and Barriers to the Adoption of Sustainable Chemistry Poster Session (TA051)

For more detailed information regarding the Spring meeting SEF programming, see the SEF website: http://webpages.eng.wayne.edu/~as8971/AIChE_SEF/conference.htm

AIChE 2008 Spring Meeting – Sustainability Short Courses

Introduction to Total Cost Assessment: How do you measure sustainability? What can we do beyond life cycle measurements? Participate in this course if you want to learn how to measure and benchmark sustainability. Presented by Lise Laurin, EarthShift.

Date: Sunday, April 6th

Time: 9:00 a.m. - 5:00 p.m.

Location: New Orleans Convention Center, Room 297

Cost: \$499/person

Sustainability Roadmap for Industry, by Industry:

Carol English from Cytec presents the sustainability roadmap developed by the industrial members from the Center for Sustainable Technology Practices.

Date: Tuesday, April 8th

Time: 4:00 p.m. - 6:30 p.m.

Location: New Orleans Convention Center, Room 285

Cost: \$99/person

If you are interested in participating in either of these short courses, register with your AIChE meetings registration, or email ifs@aiche.org.

AIChE 2008 Spring Meeting – Sustainability Luncheon

The SEF will sponsor a luncheon, organized and arranged as part of the SEF topical, during the AIChE Spring Meeting in New Orleans.

The luncheon speaker, Dane Revette, Director of Energy for the Department of Economic Development for the State of Louisiana, will discuss the Louisiana Petrochemical Megasite Project. Advanced registration is required.

Date: Thursday, April 10th

Time: 12:00 p.m. - 1:30 p.m.

Location: New Orleans Convention Center, Room 298

Cost: \$38/person

ACS 2008 National Meeting – SEF Programming

The SEF is actively participating in the ACS 2008 National Meeting, which will also take place April 6-10, 2008 in New Orleans, LA. The SEF will co-sponsor a four-session symposium entitled Engineering the Transition to the Bioeconomy. The symposium is co-sponsored by the ACS Division of Chemical Information and AIChE Sustainable Engineering Forum, Division of Fuel Chemistry, ACS and AIChE Cosponsored Programming, and Energy and the Environment

For more information, please visit the symposium website at:

<http://oasys2.confex.com/acs/235nm/techprogram/>

AIChE 2008 Annual Meeting Call For Papers

The 2008 Annual Meeting Call for Papers will be open until Sunday, May 11, 2008. Visit <http://aiche.confex.com/aiche/2008/cfp.cgi> for more information.



SEF will sponsor three topical sessions, a Sustainability Topical (Topical E), which contains 8 oral sessions, a Sustainable Biorefineries Topical (Topical 4), which includes 10 oral sessions and 1 poster session, and a Green Engineering and Sustainability in the Pharmaceutical Industry Topical (Topical 5). The SEF will sponsor this Topical in conjunction with the Pharmaceutical Division, which will include 8 oral sessions and a luncheon. The full listing of SEF programming is provided below:

Laboratories for the 21st Century (Labs21®) 2008 Annual Conference and Call for Presenters

The Laboratories for the 21st Century (Labs21®) 2008 Annual Conference will take place from September 16–18, 2008, at the San Jose McEnery Convention Center in San Jose, CA.

Labs21, co-sponsored by the International Institute for Sustainable Laboratories (I²SL), the U.S. Environmental Protection Agency (EPA), and the U.S. Department of Energy (DOE), provides a unique forum for industry leaders and professionals to discuss the challenges and opportunities facing sustainable laboratory design, construction, and operation worldwide.

For more information please visit the Labs21 website at www.labs21century.gov/conf or contact Mr. Phil Wirdzek by phone, (703) 841-5484, or e-mail, labs21@i2sl.org.

Topical E: Sustainability

| Session | Chairs | Chairs E-Mail |
|---|----------------|---|
| Design for Sustainability | M. El-Halwagi | el-halwagi@tamu.edu |
| | U. Diwekar | urmila@vri-custom.org |
| Practical Approaches to Sustainability and Business Success | S. Veith | susanne.r.veith@usa.dupont.com |
| | J. Xiao | jiexiao@wayne.edu |
| Sustainability Plenary | S. Sikdar | sikdar.subhas@epa.gov |
| | Y. Huang | yhuang@wayne.edu |
| Sustainable Fuels | R. Pike | pike@lsu.edu |
| | T. Yonemoto | toshiy@rpel.che.tohoku.ac.jp |
| Systems Analysis of Sustainability | A. Karunanithi | karunanithi.arunprakash@epamail.epa.gov |
| | K. Mochidzuki | mochi@iis.u-tokyo.ac.jp |
| Sustainable Energy | W. Barrett | barrett.williamm@epa.gov |
| | K. Liu | liuk@research.ge.com |
| Sustainability Education | R. Hesketh | hesketh@rowan.edu |
| | M. Eden | edenmar@auburn.edu |
| Prediction of Sustainability Performance by Computation | P. Blowers | blowers@enr.arizona.edu |
| | M. Goto | mgoto@kumamoto-u.ac.jp |

Topical 4: Sustainable Biorefineries

| Session | Chairs | Chairs E-Mail |
|---|-------------|------------------------|
| Sustainable Biorefineries Plenary Session | B. Dien | dienb@ncaur.usda.gov |
| | D. Thompson | david.thompson@inl.gov |
| Sustainable Biomass Feedstock Production and Supply for the Emerging Biorefinery Industry | J. Hess | JRichard.Hess@inl.gov |
| | T. Richard | trichard@psu.edu |
| Catalytic Conversion of Renewable Resources to Synthesis Gases and Pyrolysis Oils | T. Foust | thomas_foust@nrel.gov |
| | J. Cobb Jr. | cobb@enr.pitt.edu |

Topical 4: Sustainable Biorefineries (cont'd)

| Session | Chairs | Chairs E-Mail |
|--|-------------------|-----------------------------------|
| Pretreatment of Lignocellulosic Biomass and Interactions with Other Processing Steps | R. Elander | richard_elande@nrel.gov |
| | B. Dien | dienb@ncaur.usda.gov |
| Reactor Engineering for Biomass Feedstocks | M. Antal Jr. | mantal@hawaii.edu |
| | Y. Matsumura | mat@hiroshima-u.ac.jp |
| | K. Mochidzuki | mochi@iis.u-tokyo.ac.jp |
| Biological Conversions and Processes for Renewable Feedstocks | M. Moniruzzaman | mmoniruzzaman@bioenergyllc.com |
| | N. Qureshi | QURESHIN@ncaur.usda.gov |
| Chemical and Catalytic Conversions and Processes for Renewable Feedstocks | D. Miller | millerd@egr.msu.edu |
| | S. Stagg-Williams | smwilliams@ku.edu |
| Integrated Processes for Biochemical Conversion of Renewable Feedstocks to Fuels and Chemicals | N. Mosier | mosiern@purdue.edu |
| | K. Taconi | taconik@email.uah.edu |
| Developments in Biobased Alternative Fuels | B. Duff | bduff@bbibiofuels.com |
| | M. Rajchel | Marcus.Rajchel@forerunnercorp.com |
| Life Cycle Analysis of Renewable Feedstock-Based Processes and Products | D. Shonnard | drshonna@mtu.edu |
| | C. Alles | carina.alles@usa.dupont.com |
| Poster Session: Sustainability and Sustainable Biorefineries | C. Perkins | Christopher.Perkins@colorado.edu |
| | D. Thompson | david.thompson@inl.gov |

Topical 5: Green Engineering and Sustainability in the Pharmaceutical Industry

| Session | Chairs | Chairs E-Mail |
|---|---------------------|-------------------------------|
| Green Engineering and Sustainability in the Pharmaceutical Industry | R. Hesketh | hesketh@rowan.edu |
| | M. Savelski | savelski@rowan.edu |
| | C. Slater | slater@rowan.edu |
| Benign/Safer Solvents in Pharmaceutical Processing | D. Constable | David.c.constable@gsk.com |
| | S. Katti | sanjeev.katti@genzyme.com |
| Pharmaceutical Environmental Metrics - LCA | C. Jimenez-Gonzalez | conchita.j.gonzalez@gsk.com |
| | C. Slater | Slater@rowan.edu |
| Green Reactions in the Pharmaceutical Industry | Kim Albizati | kim.albizati@bioverdant.com |
| | S. Katti | sanjeev.katti@genzyme.com |
| The Business Case for Sustainability in the Pharmaceutical Industry | A. Lee-Jeffs | aleej@corus.jnj.com |
| | J. Leazer | john_leazer@merck.com |
| Government Programs and Partnerships | N. Nguyen | nguyen.nhan@epa.gov |
| | R. Engler | engler.richard@epa.gov |
| Batch to Continuous Pharmaceutical Processing Challenges | D. Pilipauskas | daniel.pilipauskas@pfizer.com |
| | F. Muzzio | muzzio@soemail.rutgers.edu |

Topical 5: Green Engineering and Sustainability in the Pharmaceutical Industry (cont'd)

| Session | Chairs | Chairs E-Mail |
|---|---------------|---------------------------|
| Green Separations in the Pharmaceutical Industry | A. Marchut | alexander.marchut@bms.com |
| | M. El-Halwagi | el-halwagi@tamu.edu |
| Green Engineering and Sustainability Engineering Luncheon | R. Hesketh | hesketh@rowan.edu |
| | M. Savelski | savelski@rowan.edu |
| | C. Slater | slater@rowan.edu |

Upcoming SEF Virtual Meeting

The AIChE Institute for Sustainability (IfS) and ASME invite participation in their upcoming webcasts on sustainability:



March 20, 2008, 10 a.m. EST: Livestocks' Long Shadow
 April 22, 2008, 2 p.m. EST: Earth Day and Sustainability
 May 22, 2008, 10 a.m. EST: Coal to Liquids and Coal Gasification
 June 24, 2008, 2 p.m. EST: Sustainability and Engineering Ethics

Anyone with discussion contributions for the upcoming March 20th "Livestocks' Long Shadow" meeting are encouraged to send them to Earl Beaver at Erbeav@aol.com. For more information regarding each virtual meeting or to register, contact ifs@aiche.org.

Past SEF Virtual Meetings

Information regarding past and upcoming virtual meetings is available on the SEF website (http://webpages.eng.wayne.edu/~as8971/AIChE_SEF/workshops.htm). Please contact Earl Beaver if you are interested in a detailed summary of the main discussion points from these previous virtual meetings or for suggestions for future virtual meeting topics.

AIChE Boston – Clean Energy Dinner and Roundtable Discussion

The AIChE Boston section will be hosting a dinner and round table discussion on the topic of "Realistic Solutions to Today's Energy Problems" on Thursday, April 3, 2008. Participants will include engineers from academics, industry, and government, responsible for developing energy policies focused on the "barriers to commercialization of Clean Energy technologies."

Specific areas of discussion include various forms of alternative energy solutions, conservation, K-12 energy & environmental programs, and environmental sustainability issues.

The discussion will be a working session, with the desired outcome being some unbiased guidelines for industry and government. Pre-registration is required.

Date: Thursday, April 3, 2008
 Time: 5:30 PM – 9 PM
 Location: Holiday Inn, Boxboro, MA
 242 Adams Place (I-495 exit 28)
 Boxborough, MA 01719
 (978) 263-8701
 Cost: Students - \$25
 Local Section Members - \$30
 Non-Members - \$35
 RSVP: No later than Tuesday, April 1, 2008
 (there will be a \$10 fee for late registrations)

For more information or to register, please visit:
http://aicheboston.s400.sureserver.com/events/event_detail.php?eventId=41

SEF ACTIVITIES

SCPPE 2007 - Workshop on International Collaboration on Sustainable System Engineering Research

Summary Prepared by Luke Achenie

The First International Symposium on Sustainable Chemical Product and Process Engineering (SCPPE 2007) was successfully held at South China University of Technology, Guangzhou, China, from September 25–28, 2007. The National Science Foundation, China (NSFC), National Science Foundation, USA (NSF), and Guangzhou Association of Science and Technology sponsored the symposium, which was well attended by numerous SEF members.

The symposium included two specially designed workshops, which were both held on September 28,

2007. The outcome from the first workshop, Discussions on International Collaboration of Research, is provided below.

Co-chairs

- Prof. Luke Achenie, Virginia Tech, Blacksburg, Virginia, USA, achenie@vt.edu
- Prof. Zhong Li, South China University of Technology, Guangzhou, China

Panelists (China)

- Prof. Hongxin Shi of Zhejiang University
- Prof. Haihui Wang, South China University of Technology
- Prof. Hongxia Xi, South China University of Technology

Panelists (International)

- Prof. Bhavik Bakshi, Ohio State University, bakshi.2@osu.edu
- Prof. dr. Ton Broekhuis, University of Groningen, Netherlands, a.a.broekhuis@rug.nl
- Dr. Maria Burka, National Science Foundation, USA, mburka@nsf.gov
- Prof. Edward Cussler, Univ. of Minnesota, MN, USA, cussl001@umn.edu
- Prof. Rafiqul Gani, Danish Technical University, Lyngby, Denmark, rag@kt.dtu.dk
- Prof. Ignacio Grossmann, Carnegie Mellon University, Pittsburgh, PA, USA, grossmann@cmu.edu
- Dr. Subhas Sikdar, U.S. EPA National Risk Assessment Research Laboratory, Cincinnati, OH, sikdar.subhas@epa.gov

Summary of Discussions

There was a very lively discussion on each of the topics below. The topics were rearranged and condensed from the original list in order to reflect the synergies and overlaps.

1. Why is international collaboration in research needed?
2. What are the roadblocks to international collaborations?
3. What are potential sources of funding?
4. What are the critical areas for collaboration in engineering?
5. What role can cyber-infrastructure play?

Why is international collaboration in research needed? What's the big picture?

International collaboration between individuals and small teams has been evolving for the last two decades. The pace picked up when the world became interconnected via global commerce, ease of travel,

the Internet and advances in global communication.

Collaborating teams saw the need to assemble together to tackle increasingly larger engineering and societal problems that impeded economic growth. One example of such problems is sustainability (environmental and resource), which is common to all nations. Sustainability shows itself in the form of green chemistry, pollution prevention, efficiency of resource utilization, water management, renewable energy and other such forms.



There is little doubt that international collaborations help advance science and technology at a faster pace than could be achieved in 20th century. In spite of this, each collaborating partner would need to determine what immediate benefit they would receive, if any. For example the challenges of using biomass vary from one area of the world to the other. What would a developing country gain from collaborating? What would a developed country gain? These sorts of questions largely determine the composition of the team.

Perhaps there is a need to look at the broader issue of collaboration in research *and* education. One reason for this coupling is the fact that research is likely to progress more quickly if each member of the team has similar or equivalent level of knowledge. The panel agreed that research collaborations should not be mandated but should come from the ground up. However, institutions can play a role by fostering an environment that is conducive to (or catalytic for) such interactions.

The level of collaboration typically involves short and medium visits of post-doctoral and early career faculty. This can escalate to collaborations involving mid to late career (i.e. established) faculty. The governments or high-level entities of two countries can establish a memorandum of understanding that facilitates collaborative research activities.

What are the roadblocks to international collaborations?

The overwhelming consensus is that the *disposable time* available to the members of the collaborating team is the top roadblock with regard to international collaborations; financial resources and intellectual property issues are the runner-ups. To a significant extent the use of modern communication tools (namely, internet, cell phone) leads to efficient time

management. Nonetheless, there is little doubt that the effectiveness of the team is maximized through one-on-one or face-to-face meetings. One can argue that tele-conferencing (through for example Skype technology) is a close substitute for face-to-face meetings.

Intellectual property (IP) is the equivalent of a minefield; one needs to tread it very carefully. A complicating issue is the fact that the attitude towards IP differs from region to region. There is evidence that research institutions (most notably research universities, research institutes and national laboratories) are filing patents at an accelerating rate. While this shows increased (and therefore good) research productivity, it also points to a significant level of mistrust among researchers. If the objectives for collaboration are clearly laid out, then IP agreements can relatively easily be written up. In addition, avoiding the frontiers of innovation (for example the Nanotechnology-Biotechnology-Information technology trio) is likely to result in fewer IP issues.

What are potential sources of funding?

The lack of funding can easily terminate collaboration. In the United States, sources of funding for international collaborative activities include the National Science Foundation (NSF), the Department of Energy (DOE), the Environmental Protection Agency (EPA), the Fulbright Program and Industry. While US Federal Agencies (e.g. NSF, DOE and EPA) are the main sources for University Researchers, industry plays a significant role by supporting doctoral and post-doctoral studies of individual students and providing internships. In the European Union (EU) research collaborations often involve EU universities and industries. However there are a significant number of projects involving EU and non-EU countries. The German National Science Foundation promotes international training networks. The Chinese government sponsors over 5,000 students who study abroad. In certain Chinese Universities (for example South China University of Technology, the host of this conference), some faculty is sponsored to go abroad for short visits to participate in research. Finally, there is a joint program between the German and Chinese NSF counterparts, for research exchanges.

What are the critical areas for collaboration in engineering?

Nanotechnology (leading to molecular scale manufacturing), Biotechnology and Information have been perceived as the critical areas for collaboration. In very recent years, however,

sustainable development has become critical since it has a worldwide impact. For example, the carbon-balance problem needs to be addressed. However, focusing only on carbon can be too narrow and lead to the adoption of products like corn ethanol, which reduce the carbon footprint at the expense of the nitrogen cycle. A more general concern is the ***disruption of biogeochemical cycles***. There is a need to improve the efficiency of routine and rather low technology operations such as the spinning of wool (in clothes manufacturing) in several developing countries. Energy, green chemistry and environmental sustenance are all very crucial goals to attain. Adding to the list are the hydrogen economy and water; the panel was unanimous in the importance of the efficient use of water. There is a shared view that ultimately the job market may help shape which areas bubble up to the top.

What role can cyber-infrastructure play?

Very recently the US National Science Foundation put together a proposal solicitation titled “Cyber-Enabled Discovery and Innovation (CDI)” which has at its basis “computational thinking”. The NSF defines computational thinking as encompassing “computational concepts, methods, models, algorithms, and tools. Collectively, CDI research outcomes are expected to produce paradigm shifts in our understanding of a wide range of science and engineering phenomena and socio-technical innovations that create new wealth and enhance the national quality of life.” It is too early to judge how fast CDI will impact international collaborations. However, it would appear that the impact on sustainable development would be monumental since the fundamental understanding of what leads to sustainable development would be gained.

EDUCATION COLUMN

Sustainable Engineering in the Capstone Design Course at Auburn University

Seay, Jeffrey R. and Eden, Mario R.

Department of Chemical Engineering, Auburn University, Auburn, AL, USA

Introduction

Sustainability and the effect chemical processes have on the environment has become a topic of considerable interest in recent years. Therefore, it is increasingly important to include these topics in the capstone design projects for chemical engineering students. The ultimate goal of any capstone design course is to encourage the students to systematically apply the methods they have learned in unit operations, reaction engineering, process

optimization, process controls and engineering economics to the conceptual design of a complete chemical manufacturing process. To these traditional methods, Auburn University has added sustainability and environmental impact assessment. By incorporating these additional elements, students have the opportunity to learn how the choices made during conceptual design impact the environmental as well as the economic performance of chemical processes.

Design Problem Background

The first process chosen to incorporate sustainability into the capstone design course at Auburn University



is based on the catalytic dehydration of bio-based glycerol^{[1][2]}.

Historically, glycerol has been produced as a byproduct of the manufacture of soap from the hydrolysis of animal fats. However more recently, glycerol has been

generated as the byproduct of biodiesel manufacture. Recently published estimates predict that the demand for biodiesel will grow from 6 to 9 million metric tons per year in the United States and from 5 to 14 million metric tons per year in the European Union in the next few years^[3]. However, for every 9 kilograms of biodiesel produced, 1 kilogram of crude glycerol is formed as a byproduct^[4]. Therefore, the identification of novel industrial uses for this glycerol is important to the economic and environmental viability of biodiesel^[5].

It is well known that many well established chemical products and intermediates can be produced via the dehydration of glycerol. A few of the industrially important products that can be made from glycerol include Acrylic Acid, Acrolein and 1,3 Propanediol^[1]. The traditional industrial process for the production of each of these products is based on the catalytic oxidation of crude oil derived propylene. For the capstone design course, the students were asked to consider both traditional and sustainable processes.

Student Design Objectives

The capstone design project at Auburn University is team oriented, with students working in groups to meet their objectives. For each of the processes describe above, the students were given conversion and yield data for the reaction, along with the reactor operating conditions, and an overall required production rate. Each student group was required to develop a model for both a traditional and a sustainable production case. Since the project is

open-ended there is not one single final solution, which is often difficult for the students to grasp in the beginning. However, each group is required to achieve certain objectives regarding integration, and economic assessment.

The primary purpose for selecting glycerol dehydration as the basis for the capstone design project was to incorporate sustainable production processes into the curriculum. To meet this objective, the students were required to consider both the industry standard, and the sustainable production pathways. Using standard design heuristics for both processes, optimized conceptual designs were generated. The learning goal of this aspect of the project was for the students to understand which variables, feedstock choice, energy integration, production rate, etc., had the greatest influence on the sustainability and environmental impacts. Since the process economics are also considered at each step the students get rapid feedback on the effects of their design choices.

To quantify the environmental impacts of their process designs, the Waste Reduction (WAR) Algorithm was applied. The WAR Algorithm is a calculation procedure developed by the U.S. Environmental Protection Agency for quantifying the potential environmental impacts (PEI) for a given process^{[6][7]}. As part of the capstone design course, the students are instructed to incorporate the results of PEI calculation along with economic considerations when evaluating process options. Adding the PEI to the standard design heuristics ensures that the most environmentally friendly of the economically viable process options is selected. Calculation of the PEI is straightforward and provides important insight into the effect of process changes on the environmental impact.

Conclusions

As a result of including sustainability and environmental impact considerations into the capstone design course, the students were able to directly experience how the decisions made during conceptual design influence the final process. The impacts of including sustainability and environmental impact assessment in the design project were immediately reflected in the student course evaluations. In fact, the student evaluations were among the highest ever received for the capstone design course at Auburn University. In response to the excellent student evaluations the inclusion of sustainability will be continued in future capstone design projects.

References

1. Seay, J., Eden, M., D'Alessandro, R., Weckbecker, C., "Sustainable Production of Industrial Chemical Products from Bioresources", *Computer Aided Chemical Engineering*, 21A, 961-966 (2006).
2. Seay, J., Eden, M., D'Alessandro, R., Thomas, T., Redlingshoefer, H., Weckbecker, C., Huthmacher, H., "Integration of Process Modeling with Laboratory Experiments in Conceptual Design: Bio-based Glycerol Dehydration Case Study", *Computer Aided Chemical Engineering*, 24, 485-490 (2007).
3. Blume, A. M., Hearn, A.K., "The evolution of biodiesel", *Biofuels*, 20-23 (2007).
4. Chiu, C., Dasari, M., Suppes, G., "Dehydration of Glycerol to Acetol via Catalytic Reactive Distillation", *AIChE J.*, 52, 3543-3548 (2005).
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6. Young, D.M., Cabezas, H., "Designing Sustainable Processes with Simulation, The Waste Reduction (WAR) Algorithm", *Computers and Chemical Engineering*, 23, 1477-1491 (1999).
7. Young, D.M., Scharp, R., Cabezas, H., "The Waste Reduction (WAR) Algorithm, Environmental Impacts, Energy Consumption and Engineering Economics", *Waste Management*, 20, 605-615 (2000).

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SCPPE 2007 - Workshop on Sustainability Education

Summary Prepared by Mario R. Eden¹, Bin Liang² and Robert P. Hesketh³

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Sustainability and the effect chemical processes have on the environment has become a topic of considerable interest in recent years. Because of this, it is increasingly important to include these topics in the education of chemical engineering students.

As discussed above, The First International Symposium on Sustainable Chemical Product and Process Engineering (SCPPE 2007) included two workshops, which were both held on September 28, 2007. The second workshop was organized to initiate discussions and provide a forum for sharing

ideas between U.S. and Chinese faculty members. The workshop consisted of five presentations and an active panel discussion. The session was very well attended (averaging around 30 people) and many interesting ideas and views were presented and discussed by the panelists and the audience.

The workshop was chaired by Professor Mario Eden from Auburn University and Professor Bin Liang from Sichuan University. In addition to the workshop chairs, the panel consisted of:

- Prof. James Wei, Princeton Univ., USA
- Prof. Thomas Ho, Lamar Univ., USA
- Prof. Robert Hesketh, Rowan Univ., USA
- Prof. Xiaoxun Ma, Northwest Univ., China
- Prof. Lei Zhang, South China Univ., China

The presentations covered the following topics:

- Incorporating Sustainability in Undergraduate Curriculum – Robert Hesketh
- General Undergraduate Chemical Engineering in China – Bin Liang
- Chemical Engineering Program at South China University – Lei Zhang
- Incorporating Sustainability in Capstone Design Projects – Mario Eden
- Developing a Graduate Program in Sustainable Engineering – Thomas Ho

In the first presentation, Hesketh provided a comprehensive overview of opportunities for incorporating principles of sustainability in a variety of undergraduate chemical engineering courses. Professor Hesketh showed several examples of materials developed at Rowan University and encouraged all the participants to visit the *Green Engineering* website (<http://nebula.rowan.edu:82/>), which contains many companion examples and homework problems that can be used to augment traditional chemical engineering text books with a sustainability angle.

Liang's presentation gave an overview of the recent developments and curriculum changes as adopted by most of the Chinese universities, with particular emphasis on how sustainability issues and principles of green chemistry have been implemented.

This presentation was followed by Zhang's overview of the School of Engineering at South China University of Technology. The immense size/enrollments of the Chinese universities in general and Chemical Engineering in particular was very impressive to the US participants.



It is during the conceptual design stages that process engineers have the greatest opportunity to influence the overall sustainability and environmental impact of a chemical process. Therefore, an assessment of these factors should be included into the standard design heuristics commonly employed to develop conceptual process options. Eden's presentation provided an illustration, by case study example, how an assessment of the sustainability and potential environmental impact can be included in a typical student design project. The case study example employed to illustrate this technique is based on developing processes for the manufacture of industrial chemical products from the glycerol generated as a byproduct of the manufacture of biodiesel. In terms of energy production, biodiesel has been shown to have an overall positive lifecycle energy balance. Therefore the use of biodiesel and its byproducts may have a positive impact on global climate change. Recently published estimates predict that the demand for biodiesel will grow from 6 to 9 million metric tons per year in the United States and from 5 to 14 million metric tons per year in the European Union in the next few years. However, for every 9 kilograms of biodiesel produced, 1 kilogram of crude glycerol is formed as a byproduct. Due to its high viscosity, glycerol must be removed from the biodiesel product, thus reducing the carbon utilization. Therefore, the identification of novel industrial uses for this glycerol is important to the economic viability of biodiesel. In this classroom case study example, the Waste Reduction (WAR) Algorithm, developed by the U.S. Environmental Protection Agency is integrated into the conceptual design of two alternative processes for the manufacture of industrial chemical products via the catalytic dehydration of glycerol. The presentation showed that by using an integrated methodology, the choices made during conceptual process development could include sustainability and potential environmental impacts, while not neglecting the important economic considerations typically used to guide the selection of the preferred process option.

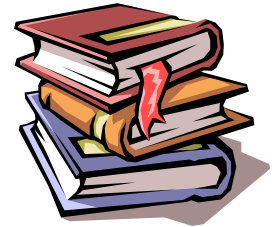
In the final presentation, Ho gave an overview of the challenges and potential pitfalls involved in establishing a novel chemical engineering graduate program at Lamar University that is focused on sustainable engineering principles. The presentation spawned a lot of discussion among the participants about how to make sustainability an integral part of both research and education at both the undergraduate and graduate levels.

In summary, the workshop was considered by everyone involved to have been a success on many levels. Practical examples of how to incorporate sustainability in a variety of courses were provided and the participants were able to network with active researcher and educators in this important area.

MEMBER COMMUNICATIONS

Sustainability Readings

Lists of valuable sustainability related reading materials, as assembled by Earl Beaver, are available on the SEF website. Anyone interested in learning more regarding the areas of sustainability, global climate change, and how sustainable companies make decisions, please see:



http://webpages.eng.wayne.edu/~as8971/AICHe_SEF/Readings.htm

2007 AIChE Annual Meeting Recap

The 2007 Annual Meeting in Salt Lake City, UT was extremely successful and full of informative discussions and presentations. The SEF sponsored two topical sessions, Topical E: Sustainability (Co-Sponsored by The Society of Chemical Engineers, Japan (SCEJ)) and Topical 4: Sustainable Biorefineries. Please visit the following websites for full SEF sponsored programming activity listings.

- **Topical E: Sustainability**
<http://aiche.confex.com/aiche/2007/techprogram/D1207.HTM>
- **T4 Topical 4: Sustainable Biorefineries**
<http://aiche.confex.com/aiche/2007/techprogram/D1200.HTM>

IFs UPDATES

Subhas Sikdar Named Chair of the Institute for Sustainability

The Institute for Sustainability (IfS), an AIChE technological community, has appointed Dr. Subhas K. Sikdar, associate director for science for the National Risk Management Research Laboratory of the U.S. Environmental Protection Agency, as the new Chair of IfS for 2008/9.

"I am honored to accept the position as Chair of The Institute for Sustainability," said Dr. Sikdar. "The Institute is critical to furthering the adoption of sustainability concepts into engineering education, research and development, measurement tools and

frameworks to guide the design of more sustainable products and processes. I am thrilled to be a part of such an impactful organization and look forward to achieving many milestones this year.”

Before joining the EPA in 1990, Dr. Sikdar held managerial positions at the National Institute of Standards and Technology and General Electric Corporate Research & Development Center. He has won numerous awards including three EPA bronze medals, an R&D 100 award, AIChE’s Larry Cecil Award for Environmental Chemical Engineering, and the Distinguished Engineering Alumnus Awards from the University of Calcutta and University of Arizona.

Dr. Sikdar has published more than 70 technical papers in respected journals, has 23 U.S. patents, and has edited 13 books. He is the founder and the co-editor-in-chief of the international journal *Clean Technologies and Environmental Policy* published quarterly by Springer Verlag of Germany.

For more information about the Institute for Sustainability, please visit:

<http://www.aiche.org/IFS/About/Index.aspx>

AIChE Institute for Sustainability Launches the AIChE Sustainability Index™

The American Institute of Chemical Engineers (AIChE), through its Institute for Sustainability, has published a new Sustainability Index that assesses sustainability of the chemical industry.

“The AIChE Sustainability Index^(sm) is an important tool that can help chemical companies benchmark their sustainability performance in many important areas against a group of their peers,” said Calvin Cobb, chair of the Index’s Advisory Board and former president of Wright Killen & Company. Cobb was a creator of the Refinery Survivability Index. “Our research shows that larger companies, and those with brands well known to consumers, tend to receive greater stakeholder pressure to commit themselves to broad and aggressive sustainability goals, and we want to provide tools to guide them down that road.”

Eleven chemical companies (Air Products, Akzo Nobel, Ashland, BASF, Celanese, Dow, DuPont, Eastman, Lyondell, Praxair, and Rohm and Haas) were included in the inaugural analysis. The larger companies – those with annual revenues above \$10 billion -- were found to lead on aspects of environmental performance and social responsibility

and had made significant progress in reducing resource use and emissions. On the other hand, some of those companies lag behind their counterparts, which have annual revenues of less than \$10 billion, in various workplace and process safety metrics.

AIChE created the new index after seeing increased interest in its sustainability programs and realizing that other sustainability indices focus on financial and social metrics. The technical and engineering components are needed to make industrial processes more sustainable, Cobb explained.

“Our research showed that other indices do not delve deeply enough into companies’ operations, engineering, research and other business processes,” added Darlene Schuster, AIChE’s director of the Institute for Sustainability and the engineer who managed its development. “We saw a real need to fill this gap and, in particular, we wanted to show how important innovation is to meeting sustainability goals.”

While the AIChE Sustainability Index initially focused on global chemical companies and the U.S. chemical manufacturing sector, Schuster explained that the index is being expanded, under a grant from the United Engineering Foundation, to include other industrial sectors. Work is underway to measure the performance of the engineering construction and the electric power industries. An advisory board composed of representatives from companies, non-governmental environmental organizations, the World Bank, and technical and business publications is overseeing further development of the Index.

Individual companies may subscribe to the index to learn how they compare to their peers by contacting ifs@aiiche.org. The index is being published twice annually in *Chemical Engineering Progress (CEP)* magazine.

AIChE Energy Metrics Project

The American Institute of Chemical Engineers (AIChE) has undertaken an effort to develop and refine tools that can help policy makers and researchers better assess the plusses and minuses of energy alternatives. “This energy metrics project will provide a sound basis for evaluating energy systems, guiding technology development, and informing public policy,” said Philip W. Winkler, chair of AIChE’s Government Relations Committee and an executive with Air



Products and Chemicals. “While it aims for both national and global perspectives, it’s also designed to be applicable to local business decisions,” he added.

Recently, Paul D. Stone joined AIChE as its Washington, DC-based consultant. Stone, an experienced executive in chemical industry research and development whose work at the Dow Chemical Company entailed interaction with federal R&D programs in essentially all government agencies, will focus on communicating AIChE’s energy metrics to federal agencies and congressional staff. “Currently, different parties compare technologies and come to different conclusions, using different baselines, data, and problem boundaries,” Stone explained.

Due to the size and complexity of the nation’s energy challenges, the chemical engineers are taking a staged approach, with an initial focus on biomass to energy systems. They expect to provide a constructive reference case for setting boundaries to be considered when evaluating energy systems: material and energy balance flows, the selection of key assumptions (e.g. today’s performance versus potential capability), and constraints and trade-offs.

The energy metrics effort is part of a larger AIChE energy initiative. Energy metrics is an important part of this initiative, according to AIChE’s President Dale L. Kearns, a technical fellow with SAIC, since “selection of the ‘right’ solutions is an immense optimization problem with innumerable variables and subjective, as well as objective, criteria.”

Given the interdisciplinary nature of the energy challenge, Kearns says that AIChE will be engaging other engineering societies in the metrics effort. Because societal issues need to be considered, as well as technical ones, the committee is also discussing how to involve non-technical organizations in the process of energy system evaluation. For additional information or to become involved with this project, contact ifs@aiiche.org.

Center for Sustainable Technology Practices

The Center for Sustainable Technology Practices has launched an impressive list of projects to be initiated in 2008. Led by Carol English, of Cytec, Inc. and Dickson de la Haye of Dow Chemical, the industry consortium is focusing on best practices for implementing sustainability concepts into industrial practice. The projects include: The CSTP Sustainability Roadmap will be published in 2008, and it can support organizations that are either

interested in integrating new sustainability considerations into their Business or enhancing existing sustainability-related initiatives. The Roadmap Is flexible, may be edited, and was developed such that users can customize the tool for use by their specific organization. Dave Taschler of Air Products and Jack Gustashaw of Middough are surveying use of metrics tools available for use by industry, and Charlene Wall of BASF is coordinating an impressive list of monthly teleconference focusing on various educational aspects for implementing sustainability into industry. For additional information or to discuss how CSTP membership can benefit your company, contact: ifs@aiiche.org.

Youth Council on Sustainable Science and Technology (YCOSST)

YCOSST is in the final stages of exploring the needs and opportunities of creating YCOSST student chapters at colleges across the US. These chapters would be open to students, from all disciplines across college campuses, interested in incorporating sustainability into ALL undergraduate curriculum and research. Interested students and faculty should contact YCOSST chairs, Katelyn Keefe, Lyn Beary, and Marco Calstaldi at YCOSST@aiiche.org.

SEF LEADERSHIP (2008-2009)

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