MICHIGAN STATE UNIVERSITY

# Biosystems Engineering

## 2010 Biosystems Design Project Showcase

April 15, 2010

Kellogg Center

Michigan State University

### Biosystems Engineering

*Biosystems engineers integrate and apply principles of engineering and biology to a wide variety of socially important problems. The MSU biosystems engineering program prepares graduates to:*

- *identify and solve problems at the interface of biology and engineering, using modern engineering techniques and the systems approach and*
- *analyze, design, and control components, systems, and processes that involve critical biological components.*

*MSU biosystems engineering graduates are having a positive impact on the world, working in areas such as ecosystems protection, food safety and biosecurity, bioenergy, and human health.*

BIOSYSTEMS and Agricultural Engineering

*Integrating Engineering and Biology Since 1906*

# Participants / Agenda

## Biosystems Design Project Participants

*Joseph Ahlquist*
*Jonathan Biron*
*Natalie Bouchard*
*Brandon Coles*
*Louis Faivor*
*Gerald Hessell*
*Yvette Holly*
*Amber Jablonski*
*Andrew Johnson*
*Johanna Kinsler*
*Julio Martinez*
*Nancy Maschke*
*Jason McIntyre*
*Dara Phillips*
*Andrew Sommerlot*
*Matthew Stinson*
*Patrick Triscari*
*Michael Wandersee*
*Bradley Wardynski*

## A Showcase of the Program and Students

**April 15, 2010**

Presented by
Faculty and Students in the Biosystems Engineering Program
College of Engineering
College of Agriculture and Natural Resources
Michigan State University
East Lansing, Michigan

**PROGRAM**

The Kellogg Center at Michigan State University

**Red Cedar A & B**

2:00 p.m. - 2:15 p.m. Briefing of Industry Participants on Program Assessment
2:15 p.m. - 2:30 p.m. Break

**Big 10 Room B & C**

2:30 p.m. - 4:30 p.m. Senior Student Design Presentations
4:30 p.m. - 4:45 p.m. Break
4:45 p.m. - 5:45 p.m. Concurrent Project Review Panels
5:15 p.m. - 6:30 p.m. Reception/Student-Industry Interaction and BE 230 Poster Presentation

**Lincoln Room**

6:45 p.m. - 8:30 p.m. Dinner

# 2010 Scholarship Recipients

## Undergraduate Awards

***F.W. Bakker-Arkema Endowed Scholarship***
Lara Ejups

***A.W. Farrall Scholarship***
(presented at the CANR Honors Banquet)
Ellen Bornhorst
Kevin Koryto

***Clarence & Thelma Hansen Scholarship***
(presented at the CANR Honors Banquet)
Bridget Bednark
Michael Schierbeek

***Howard & Esther McColly Scholarship***
Alexa Jones

***George & Betty Merva Scholarship***
Shannon Henderson

***Biosystems Engineering Outstanding Undergraduate Researcher Scholarship***
James MacLellan

## Graduate Awards

***BAE Fellowship Award***
Haiyan Cen

***Merle & Catherine Esmay Scholarship***
Irwin R. Donis-Gonzalez

***Bill & Rita Stout Scholarship***
Edith Torres-Chavolla

# Team Projects

## Nestle Aseptic Filler

The Nestle-Gerber pilot-plant requires an efficient sterile, or aseptic, process for filling a diverse array of products into varying sized and shaped packages for research and development testing. An aseptic filling environment needs to be designed, constructed, and validated for implementation in the pilot plant.

This design includes four components: chambers, sterilization system, product filler, and controls. Three connected chambers are used to isolate and sterilize packages for filling. Next, sterilization is performed using vaporized hydrogen peroxide (VHP). The filler loads packages precisely with a predetermined volume. An electronic interface controls and monitors temperature, relative humidity, hydrogen peroxide concentration, air flow rates, and internal chamber pressure.

Theoretical results are simulated using computational fluid dynamics modeling software. With this model, a baseline VHP cycle time is established to optimize the sterilization process and assure sufficient surface contact. The goal is to prove a 4-log reduction of microbial pathogens. Economic analysis is used to optimize the design for long-term operations.

Statistical testing of the pathogen reduction inside the filling chamber will be completed on site. Standard operating procedures will be established to assist operators in using the aseptic filler properly. Documentation of the project is recorded to help Nestle operate and maintain the aseptic filling chamber.

BAE
Department of Biosystems and Agricultural Engineering

Nestlé


## Design Team

**Team Members** (left to right)
Jonathan Biron, Brimley, MI
Gerald Hessell, New Haven, MI
Matthew Stinson, Kalamazoo, MI

**Faculty Advisor**
Kirk Dolan
MSU Food Science & Human Nutrition
MSU Biosystems & Agricultural Engineering

**Sponsor/Mentor**
Ferhan Ozadali,
Nestlé Nutrition R&D

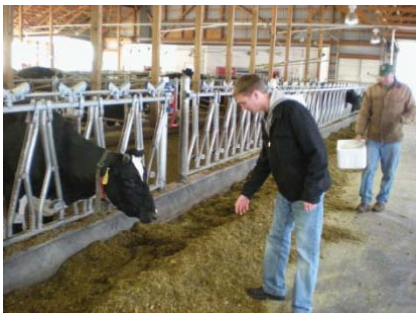
**Industry Advisors**
Cassaundra Edwards,
Kraft Foods/
Oscar Mayer R & D
Scott Millsap,
JBT Food Tech
Mike Potts,
General Mills

# Integrated Anaerobic Digester and Treatment Wetlands for Pasture Based Dairy Farms

The objective of this project is to utilize mathematical models to develop and optimize a preliminary engineering design that produces renewable energy while also biologically treating waste. This project focuses on the design of an anaerobic digester coupled with a treatment wetland for small dairies using the Kellogg Biological Station (KBS) as a case study.

Because KBS is a pasture based dairy farm, manure from its 100 lactating cows is only available in significant quantities during winter months, when the cows are housed inside. Results predict that sufficient manure is not available for the production of large amounts of gas for electricity or heat generation. However, by adding wetland plant material, such as duckweed grown in the treatment wetland, to the digester during the summer months, this project could be economically feasible.

Designing a comprehensive waste management system for any small farm requires a substantial capital investment. Additional and sometimes nontraditional methods will be needed to achieve sustainability.



## Design Team

**Faculty Advisor**
Wei Liao
MSU Biosystems & Agricultural Engineering

**Team Members** (left to right)
Louis Faivor, St. Johns, MI
Joe Ahlquist, Troy, MI
Patrick Triscari, Farmington Hills, MI

**Sponsor/Mentor**
Dawn Reinhold,
MSU BAE

EPA P3 Competition Proposal

**Industry Advisors**
Michelle Crook, Michigan Dept. of Agriculture
Chad Ducey, e-biofuels
Dave Prouty, Heat Transfer International

# Determining Restriction Potential & Engineering Alternatives for Carcinogenic Substances

Under the growing concern for global health safety and environmental sustainability, various regulatory agencies, such as the U.S. Environmental Protection Agency (EPA) and European Chemicals Agency (ECHA), are seeking to restrict the use of substances shown to be hazardous to humans and/or the environment. Inconsistencies in the restriction criteria exist between agencies and the lists are frequently updated as new information is found. Abbott Labs is seeking a standardized method of predicting restriction potential in order to determine whether the substances of concern used in their manufacturing of products or packaging are likely to become restricted and a procedure to evaluate alternatives.

In order to accomplish this goal, a flow chart model was developed to determine restriction probability of carcinogenic compounds of concern to Abbott. By integrating toxicological research on currently restricted substances from the International Agency for Research on Cancer (IARC) and U.S. regulatory agencies, the model assesses restriction probability on a global and qualitative scale. Carcinogens of concern to Abbott, deemed to yield the highest restriction probability, were quantitatively assessed in order to recommend sustainable alternatives.

Abbott seeks to be proactive about assessing the increase in global restriction of hazardous chemicals. Thus, the developed prediction model will serve as a foundational method for addressing such regulatory concerns and provide the means to predict chemicals that may be restricted in the future.

## Design Team

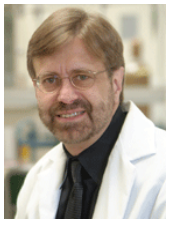
**Team Members** (left to right)
Brandon Coles, Novi, MI
Dara Phillips, Southfield, MI
Yvette Holly, St. Clair Shores, MI

**Sponsor/Mentor**
Christopher L. Sprague, Abbott

**Industry Advisors**
Steve Steffes, Perrigo
Paul J. Eisele, Private Consultant
Rebecca Leaper, Abbott

### Faculty Advisors

Evangelyn Alocilja
MSU Biosystems & Agricultural Engineering



James Pestka
MSU Food Science & Human Nutrition

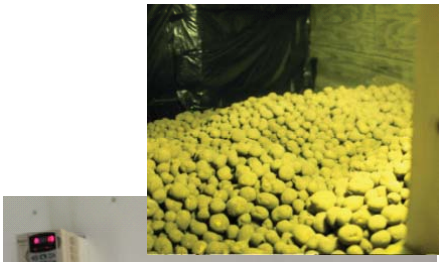
# Design for Improving Air Exchange in Potato Storage

Potatoes are cooled and stored in bulk storage for 1 to 12 months after harvesting and before being processed into potato chips. Respiration occurs during storage; the sugar in the potatoes combines with oxygen in the air to produce carbon dioxide, water, and heat.

Glucose + Oxygen ➔ Carbon Dioxide + Water + Heat

Proper air exchange removes carbon dioxide and heat while retaining the potato moisture content, which provides a higher yield when sold. Techmark, Inc., advises farmers on ventilation techniques and is therefore, interested in how variable frequency drive fans impact potato quality and electrical consumption requirements. The objective of this project is to use an air, heat, and mass transfer computer model to design an improved fan setting strategy. Computational Fluid Dynamic modeling is used to show how pressure differentials through the potato pile relate to the air flow, which corresponds to the respiration of the crop.

The project design uses potato characteristics and air properties, such as temperature and humidity, to solve heat and mass transfer equations. Different fan speeds are simulated to determine the most efficient strategy. Use of this model leads to improved air exchange settings, which result in reduced energy costs and improved crop yields.



## Design Team

### Team Members
(left to right)
Amber Jablonski,
Macomb, MI
Jason McIntyre,
Dowagiac, MI
Andrew Johnson,
Lakeview, MI

### Sponsor/Mentor
Todd Forbush,
Techmark, Inc.

### Industry Advisors
Kevin Evans, PepsiCo
David A. Hamilton,
MI Dept. of Natural Resources and Environment
Steve Richey, Kellogg

### Faculty Advisors
Bradley Marks (top),
MSU Biosystems & Agricultural Engineering
Fred Bakker-Arkema (bottom),
MSU Biosystems & Agricultural Engineering

# Team Projects

## Sustainable Urban Detroit Goat Farm

With the plummeting population and increase of inexpensive unused land, urban agriculture has become a business opportunity within many cities including Detroit. Goat farming provides unique opportunities for the production of meat while providing employment and educational facilities in an urban environment. However, goat farming produces problems such as managing waste and creating a sustainable cash flow. Project objectives are to create a computer model that optimizes energy inputs with meat outputs, waste management, land availability, and employment. The project constraints require a minimum of forty goats to optimize meat production with useable land that contains both pasture and feeding space within a building.

The model includes multiple Excel routines to enable the optimization of a desired inputs. One optimization option matches the number of goats desired to housing and feeding needs, expected profit, and land area required. A second option requires the amount of land available to determine the herd size, feed requirements, and net profit. The third inputs a desired profit margin and outputs the number of goats and land requirements.

Included in the model outputs are the amount of waste produced, number of goats, and the heating and space requirements. A plan to compost the waste into a desirable product (fertilizer) is also provided. To substantially reduce the odors, gas emissions from the compost will flow through a biofilter.

Results from the model found that over forty goats are required for an urban farm to be financially sustainable. Donations or grants are required to keep the business viable. However, the model contains many assumptions that should be further explored prior to construction of an urban goat farm.

**Team Members** (left to right)
Michael Wandersee, Temperance, MI
Julio Martinez, San Antonio, TX
Andrew Sommerlot, Lansing, MI

### Design Team

**Faculty Advisor**
Dana Kirk
MSU Biosystems & Agricultural Engineering

BAE
Department of Biosystems and Agricultural Engineering

Urban Agricultural Initiatives of Detroit

**Sponsor/Mentors**
Rebecca Busk
Erin Sutton
Urban Agricultural Initiatives of Detroit

**Industry Advisors**
Steve Shine, Michigan Department of Agriculture
Saied Mostaghimi, Virginia Technical University
Paula Steiner and Juanita McCann, USDA-NRCS

# Pilot Bioengineering for Stabilization of the Red Cedar River

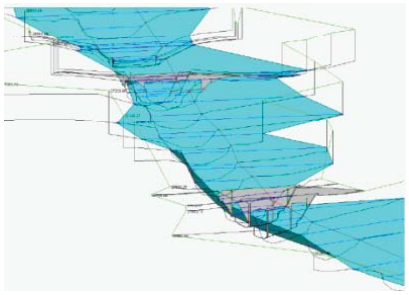
The Red Cedar River, on Michigan State University's campus, presents signs of riverbank erosion. Widening of the stream channel and bank undercutting has exposed infrastructure and damaged riparian habitat along the river corridor. The MSU-WATER Initiative requested a sustainable stabilization plan that enhances biodiversity while being resistant and resilient to flood events, cost effective, and aesthetically appealing.

In order to model the stability of the system, geomorphologic, geotechnical, and hydraulic analyses were performed. Tributary discharges and dimensions were compared, and the watershed was found to be in a state of quasi-equilibrium. Site-specific hydraulic analyses were then performed using HEC-RAS to predict key design parameters of shear stress, velocity, and water surface elevation.

A vegetated geotextile retaining wall will stabilize the steep banks and conserve existing trees. A combination of live willow cuttings, vegetated buffer strips, and "terracing" with live branches will reinforce soil and reduce sediment transport. The design provides a sustainable solution by combining mechanical stabilization with biological resilience.

Further recommendations to reestablish floodplain connectivity include the expansion of riparian buffer strips and reshaping of channel geomorphology.

Surveying Deer Creek Tributary



Hydraulic River Modeling

**Team Members** (top, left to right)
Brad Wardynski, Canton, MI
Nancy Maschke, Bad Axe, MI
Johanna Kinsler, Lake Angelus, MI
Natalie Bouchard, Trenton, MI

## Design Team

**Faculty Advisor**
Dawn Reinhold
MSU Biosystems & Agricultural Engineering

**Sponsor/Mentors**
Ruth Kline-Robach
Steve Miller,
MSU-WATER Initiative

**Industry Advisors**
Jeff Friedle, LSG Engineers & Surveyors
Valerie Novaes, Tetra Tech
Larry Stephens, Stephens Consulting Services, P.C.

# 2010 Alumni Awards

## Biosystems & Agricultural Engineering 2010 Distinguished Alumni Award

### Dorota Haman

Dorota Z. Haman is a Professor and Chair of the Department of Agricultural and Biological Engineering at the University of Florida in Gainesville, Florida. She received a B.S. degree in Mathematics from the University of Warsaw in Poland, then went on to receive her M.S. and Ph.D. degrees in Agricultural Engineering from Michigan State University. She has been working at the University of Florida since 1985.

For many years, in addition to teaching and research projects in various aspects of irrigation, she had statewide responsibilities as coordinator of irrigation and water conservation programs. She was also extension program leader for water conservation in Florida, and a recipient of the Governor's prize for energy conservation. Her research projects are focused on water conservation and implementation of water efficient technologies including microirrigation. Together with her graduate students, she has been involved in analyzing the Santa Elena Peninsula irrigation system in Ecuador and Wargal watershed near Hyderabad in India. She has also been involved in development and evaluation of FAO irrigation courses for irrigation professionals in east and southern Africa.

She has been an active member of ASABE, EWRI and several other professional organizations. She is a life member of USCID, a member of the USCID Board of Directors, and a past representative to the ICID Working Group on Capacity Building, Training and Education.

## Biosystems & Agricultural Engineering 2010 Outstanding Alumni Award

### Nick Friant

Nick joined Cargill in 2002 where he serves as the Grain Handling Coordinator for Cargill's AgHorizons and Grain and Oilseed Supply Chain – North America business units. In January 2008, Nick's role was expanded to include leading Cargill's World Wide Grain Operations Grain Quality Center of Expertise. The key responsibilities of his position are to provide technical and regulatory assistance to Operations and Merchandising personnel on a wide range of issues related to grain quality, handling, and inventory control.

Nick grew up on a small, family grain farm in north-central Illinois. The main commodities are corn and soybeans. He still enjoys going back to the farm during the planting and harvesting seasons. He attended Michigan State University where he graduated with a Bachelor of Science in 2000 and a Master of Science in 2002, both in Biosystems Engineering. His main area of study was grain quality, handling, storage, and drying.

He is a member of The American Society of Agricultural and Biological Engineers, GEAPS, the NFGA Grain Grades and Weights & Agroterrorism/Facility Security Committees, the NAEGA Grain Grades and Inspection Committee, and recently completed a three-year term on the USDA GIPSA Grain Inspection Advisory Committee (Chairperson during the third year).

Nick is married to Stephanie (MSU '98) with one son (Mason), and another child on the way. He enjoys hockey, time working in the yard, and vegetable gardening.

# Special Thanks

**2010 Biosystems Engineering Showcase Sponsor**

Abbott
A Promise for Life

**Professional Development Speakers,**
**Biosystems Design Project Class**

Vangie Alocilja, MSU Biosystems & Agricultural Engineering
Janelle Clark, Kellogg Company
Hope Croskey, MSU Biosystems & Agricultural Engineering
Kirk Dolan, MSU Biosystems & Agricultural Engineering
Chad Ducey, e-biofuels
Phil Hill, MSU Biosystems & Agricultural Engineering
Rebecca Leaper, Abbott
Wei Liao, MSU Biosystems & Agricultural Engineering
Bradley Marks, MSU Biosystems & Agricultural Engineering
Gary Mell, MSU Power Plant
Steve Miller, MSU Biosystems & Agricultural Engineering
Ferhan Ozadali, Nestlé Nutrition R&D
Wendy Powers, MSU Biosystems & Agricultural Engineering
Larry Protasiewicz, Spicer Group
Steven Safferman, MSU Biosystems & Agricultural Engineering
Don Schafer, MSU School of Planning, Design, & Construction
Chris Sprague, Abbott
Truman Surbrook, MSU Biosystems & Agricultural Engineering
Tom Volkening, MSU Engineering Librarian

Steven Safferman
**BE 485/487 Biosystems Design Project Instructor**

Hope Croskey
**BE 485/487 Professional Development Instructor**

**Technical Advisor**
Luke Reese

**Showcase Event Coordinator**
Barb DeLong

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David A. Hamilton, Michigan Dept. of Natural Resources and Environment
Rebecca Leaper, Abbott, Medical Products Group
Juanita McCann, USDA, Natural Resources Conservation Service
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Rebecca Larson, Graduate Student Representative

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